AGRICULTURAL ENGINEERING

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RAYMOND OLNEY
Editor and Business Manager

EDITORIAL

Professional Unity in Engineering

A RECENT able address on professional unity by an engineer* prompts us to further thought on the subject, and remarks somewhat aside from the points made by him.

The legal and medical professions got their start as professions when higher education was comparatively rare. Their distinction as men of learning engaged in practical work was quite clear. Their professional organizations were well founded and strong before extensive specialization developed; and grew stronger by continuing to serve the professional interests of their respective groups without regard to increasing technical specialization. And they have succeeded unusually well in lifting themselves by their boot straps.

We like to believe that engineering organization has developed in its present diversified form from natural causes, differing from those which shaped the legal and medical professions, rather than due to some abnormal perversity on the part of engineers. Technical progress in engineering, as well as the strength and achievements of the technical societies, testify strongly to their meritorious service. Possibly engineering service to humanity required technical progress and specialization first and foremost.

If, as it appears to many engineers, we now need a lever to lift ourselves by our professional bootstraps, by all means let it be under development. It will take time. Let us not be condemning each other politely for failure to unite under any one of the plans and organizations for professional solidarity thus far advanced. It would seem more in character as engineers to recognize frankly that none of these mechanisms have yet shown sufficient evident merit to win majority approval and support as a lever equal to the job. As engineers we need to look for and depend on a sound mechanism for professional unity rather than any blind group loyalty to the status quo of any one organization.

In the various discussions we have read and heard, we have gained the impression that the problem is sometimes being approached with less basic knowledge of the forces and materials involved than we might expect an embryo engineer to apply to some student laboratory problem.

No disrespect or discredit to the various authors is intended. The basic knowledge needed in this problem is not in our handbooks. Discussion is needed to start work toward getting it.

It occurs to us that improvement in the professional status of engineers may depend in a large measure on the application of sound principles in the mechanics of human organization, with particular reference to factors influencing our group capacity to serve; and that we might seek to learn more of these principles by application or extension of engineering methods other than trial and error.

As to the related problem of the economic status of engineers, it occurs to us that we need, in addition to sound knowledge of the mechanics of human organization in our field, improved knowledge of the several factors influencing our economic productivity and returns. A better yardstick might make a more constructive contribution to our economic satisfaction than either unionism or the more genteel persuasion of professional pressure.

*"Professional Unity is Possible," by Marvin C. May, assistant professor of civil engineering, University of New Mexico, before the All Engineers Conference, University of New Mexico, March, 1947, and the Southwest Conference of the American Society for Engineering Education, April, 1947.

Marketing Agricultural Residues

THE phenomenal growth and efficiency of food and feed marketing in the United States is due, in large part, to the cooperation between farmers, farm equipment manufacturers, and food and feed processors. Food and feed, however, represents less than half of the production realized on the farm; the remainder, which includes the straws, stalks, cobs, hulls, etc., under the general term "agricultural residues", is largely wasted. A part of the agricultural residues is returned to the soil and a very small portion finds industrial use, but too large a portion is discarded or burned as trash. This large waste contrasts greatly with the generally established industrial techniques of complete utilization of products and by-products. It is not only an annual economic loss which we can ill afford, but it also results in a larger drain on some of our irreplaceable natural resources.

The cellulosic and fibrous character of the majority of the agricultural residues suggests them naturally as raw materials for the paper, board, and kindred industries. A relatively small amount of wheat straw is actually used in the production of straw paper for corrugated shipping containers. Technological developments indicate that these agricultural residues are suitable for fine papers, building boards and other industrial fibrous products, if the economics of procurement of these residues is brought into line. This depends in turn, with mounting labor costs, upon improvements in the methods and machines for harvesting, collecting, and packaging of these residues.

A recent meeting at the USDA Northern Regional Research Laboratory, of representatives of the strawboard and farm equipment industries to discuss these matters is a hopeful sign and a promising step toward the economic industrial utilization of the country's vast stores of agricultural residues. Elsewhere in this isue will be found two papers presented before this meeting.

Custom Work

CURRENT increase in the variety, availability, and farm acceptance of custom work suggests a review of its significance.

Custom work may never be the ideal or ultimate setup for farm production operations. It has obvious disadvantages. But it is often a workable expedient for getting a job done to best possible advantage under existing circumstances.

At present these circumstances often include scarcity and high cost of labor, and inability to buy certain equipment, as well as peak load operations and special jobs not warranting individual farm investment in additional or special equipment. They also include the need and desire of some farmers to do part-time custom work to increase profitable use of available labor and equipment, and to provide sufficient use to justify the purchase of additional high-efficiency equipment.

Increasing acceptance of custom work further suggests a growing appreciation on the part of many farmers of some of the economic factors influencing their net returns. They are recognizing the low unit cost of work done with certain large-capacity production equipment representing a substantial investment. They are recognizing further the importance of this equipment being used close to its maximum annual capacity in order to realize its potential economy. They are recognizing the importance of timeliness in certain operations. They are recognizing the need in some cases of major operations on the face of their farms to improve their setup for effective farming.

How well the custom operators may survive an increase in availability of equipment and labor, lower farm incomes, or increasing efficiency of small equipment units, will depend on a number of factors.

The usual sound business methods will be necessary to satisfy customers and minimize collection difficulties.

(Continued on page 300)

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Agricultural Engineering in the Reconversion Period

By Mark L. Nichols
FELLOW A.S.A.E.

A LITTLE over a hundred years ago, in 1824, the first school of engineering, the Rensselaer Polytechnic Institute, was founded in Troy, New York, to "apply science to the common purposes of life." In this brief interval of time, engineering has become America's greatest skill and achievement. It provides the basis of our present high standard of living, and it supplied the sinews with which our fighting men won the victory in the last war. America's position as probably the most powerful nation in the world is the result of engineering achievements in the application of science to mass production, both in industry and in agriculture.

MARK LOVELL NICHOLS
President, A.S.A.E., 1946-47

We are banking heavily upon our engineering skill to carry us through the present turbulent period following the end of the fighting war. We in agricultural engineering have a particularly important role to play in this, since food is probably the most powerful weapon we have in the unceasing fight to maintain a free and democratic nation.

At this meeting we are primarily concerned with the affairs of the American Society of Agricultural Engineers, and it is well that we review briefly the purposes and functions of the Society.

In the first place, the Society is the clearing house for engineering ideas and the technological information which provides the basis of our engineering practices. We meet once or twice a year to talk over professional problems, to exchange ideas and viewpoints, and, as far as possible, to do joint planning for the future.

It is the function of the Society to provide a continuous record of progress in the profession. This function is ably carried out through our Society journal, AGRICULTURAL ENGINEERING.

It is also the function of the Society to conduct such promotional activities as are necessary for the general benefit of the profession.

I believe that it is the President's duty in his annual address to the Society to review the general situation from the standpoint of the profession and make such suggestions as he thinks will be of benefit to the Society in the performance of its functions.

It is very difficult to make an accurate review of the present situation. There are so many conflicting ideas of just what is happening in the world that it is impossible to feel positive as to what the real situation is. Certain things are obvious. We are still technically at war, struggling to find the way out, and at the same time to set up some type of procedure or world organization which will remove as far as possible the causes of war in the future. The pattern of the future is beginning to emerge but it is still very confused. We do not know whether we can attain the philosophy of one world or whether the grim necessity of survival will force us into two opposing camps. In any case, the situation is such that many of the people in this country feel we must have on hand a large amount of defensive armament and a well-trained and efficient military force for our own protection. It is becoming clear that the very existence of democratic, capitalistic groups of states is considered a menace by the totalitarian groups; hence, we must be prepared to fight for our lives in self-defense if the need arises.

This basic consideration is bound to affect much of our future internal development. We are told that we must develop power sources in many locations, modify and develop transportation and communication systems, and distribute production centers so as to make possible adequate defense. We have all read articles and heard discussions concerning these problems, but as yet I have not heard of any official plans for such projects.

If America is to continue to use food as a weapon, we in agricultural engineering have a great responsibility, because we must not only maintain our present productive efficiency but also increase it.

Our relations with foreign countries have materially changed. The simple fact that the services of one man can provide food and clothing for many is in large part responsible for America's prosperity and high standard of living. This fact has become so well known throughout the world that our methods are constantly being studied by groups from foreign countries. Their purchase of our agricultural equipment gives us an opportunity for expanding our implement and power industries. We shall be called upon more and more to send engineering delegations to assist other democracies to attain, in so far as their resources will permit, a similar high standard. A number of our members have already been abroad for this or like purposes.

With agricultural development abroad and increased demands at home, we can logically expect an expansion of our machinery industry. If we are to maintain leadership in this field, we must have research support for it. Our past achievements have been so notable that many Americans take this development for granted and the work receives little support from the federal or state governments. The unparalleled ingenuity and enterprise which is the outstanding characteristic of our industry and which makes possible the America we know will, we hope, continue to exist, but agricultural development must in large measure depend upon hard work in the laboratory and on the experimental plot. Public contribution to this research should be directed at those phases which constitute a public responsibility rather than a responsibility of industry — in short, the agricultural requirements which the manufacturer of machinery must meet in designing machinery, and the most efficient methods of using the machines once they are built. It is, of course, the public's responsibility to carry on research in the field of materials in relation to certain physical properties of soils and crops. In general, however, the design and production of equipment can be handled better by industry than by governmental agencies.

Perhaps an explicit example of the division of responsibility

Address of the President of the American Society of Agricultural Engineers before the 40th annual meeting of the Society at Philadelphia, Pa., June, 1947.

M. L. NICHOLS is chief of research, Soil Conservation Service, U. S. Department of Agriculture.

may be helpful here. Certainly it is the responsibility of agriculture to determine its own needs. For example, if we are to raise wheat in the Palouse region and require long-sustained use of the land, it is essential that we maintain the soil. This must be done on a sustained economic basis. It must be profitable and practicable to protect the soil against destruction by erosion and to utilize fully the water and fertility resources for maximum yield and at minimum labor and other costs.

It is unreasonable to expect the farm equipment industry to work out the needed practices. They are in the business of manufacturing machines and servicing them for the farmer — a highly competitive field. They are not engaged in farming. They are, of course, interested, cooperative and keenly appreciative of the farmer's problems. But they cannot afford to develop his practices for him or plan or manage his farm. Likewise, the individual farmer cannot afford to run an experiment station. The government must do that for him. So we have clearly indicated a logical, effective, and simple relationship among farmers, governmental agencies—whether local, state or federal—and the farm equipment industry. Many examples of this type of interdependence can be pointed out.

In the Cayuga Ridge area of Illinois, for example, the physical conditions are such that the land is deteriorating rapidly. It has been and in most cases still is highly productive and has a high valuation. It is becoming evident, however, that the erosion problems demand that continuous corn and soybean culture be abandoned or corrective measures found. Many who are familiar with this area think that new systems of land use must be developed which will give satisfactory economic return to the farmer so that he can afford to conserve the soil. Otherwise he will be forced to continue to exploit it, because it is the source of his livelihood. When the general land-use system has been determined, the machinery problems involved become apparent. Similar situations exist throughout the tobacco and cotton lands of the South.

ENGINEER TO PLAY MAJOR PART

The engineer has a major part to play in the classification and utilization of our land resource. Use of equipment determines in large part the profitableness of land use. In the first place, we must recognize that various pieces of land have various capabilities. A piece of land which is steep and rolling may be primarily adapted to pasture and woodland. Another soil and a different topography may be cultivated continuously over long periods if proper conservation practices are applied, whereby the body of the soil is protected and its fertility maintained. A few years ago a good start was made in research for farm layout by engineers but this was neglected during the war. It merits reconsideration. Proper land use must be based upon agronomy and soil technology, but it is the engineer who must develop means of making it profitable.

Most of the changes in the agriculture of the past have been brought about by a process of attrition which has been hard on the land and hard on the farmer. Are we sufficiently advanced in civilization to determine scientifically the basic causes and effects of the physical changes continually occurring in nature which affect our future before our resources are destroyed? Can we develop something analogous to preventive medicine? In the past too many of our farmers "wore out" one farm and moved west to another. Our resources are limited. We have occupied the continent to the Pacific and the time is at hand when we must decide upon many basic social and physical courses. As agricultural engineers we have a great responsibility in maintaining both our efficiency in production and the resources necessary for that production.

I believe there is general failure to comprehend the fundamentals of both the conservation and the utilization of our agricultural resources. Land properly used is improved. Improperly used, it is destroyed. Greatly increased yields can be produced without injuring the land, if only the mineral elements which are taken out by the crops and which constitute a very small portion of the land are returned, and if soil-building practices are used that keep the organic matter at a high level. Soil building follows principally the dynamic concept of growth, in which we return to the soil large quantities of organic material, a product of the land, that, in turn, gives us greater production. Through these soil-building processes a large number of areas in the United States can be made to produce many times the present yield of crops. Further, it has been proved in various sections of the country that the whole destructive process can be reversed by putting a portion of the land into soil-building and cover crops, and other portions into rotation of cultivated crops. The result has been that farmers have produced more on the cultivated areas than they did on the entire farms before such soil-building practices were established—not only produced more but at lower costs because of the smaller acreages involved and higher yields per acre.

In many areas we have certainly made sorry use of our water resources. This, in my opinion, is one of the greatest fields for the agricultural engineer. The water resources come from the rain deposited on the surface of the land. Much of our water is now used as a transportation medium to take our good earth to the seas, leaving our cities short of water supplies and our crops suffering from drought. The quantity saved for use and its condition depend upon the way the land is managed. Let us remember that the agricultural engineer is the man who determines how this should be done. Water utilization and conservation programs make possible the creation of new wealth. Conservation and storage of water enables us to bring new areas into production. Water supplies also make the production in other areas surer and more profitable. There may be a question as to the time for developing the water resources of the West for irrigation projects and as to the time for draining the swamp lands and wet lands of the East. Personally, I cannot follow the logic of postponing these developments when we are able to make them, because once water is returned to the sea it is lost forever and the production of the years that we let go by can never be recovered.

The full utilization of our resources which would otherwise be lost should not be confused with such issues as parity and equalization of farmers' income. When even a large part of our own population is not adequately nourished, there certainly must be some way to utilize these resources for the benefit of our own people and for peoples in other lands, who, in return, can do many things for us. In my judgment we should proceed not only to maintain what resources we have but to develop them to provide a fuller life for people both at home and abroad. In this we have a good lesson from the Bible in the parable of the talents.

NEED FOR INCREASED WATER SUPPLY

We have a responsibility as agricultural engineers in supplying an increasing industrial population with water. The only supply is the water that falls on the land or that comes down natural streams or artificial conduits. Stream flow, to be satisfactory for many uses, must be all-weather flow and in most areas is supplied from reservoirs deep within the earth. If the land-use practices are such that a fair portion of the rainfall is infiltrated into these underground supply centers, base flows can be maintained. The U.S. Forest Service has long been cognizant of this fact and the forests have served well in this connection. But the greater part of the land in our most important areas is not covered by forests and we must put the water into the soil in connection with our agricultural land-use practices. The soil and subsoil are the greatest existing reservoirs for storage.

We also have responsibilities in connection with flood control. It is true that we get such extreme downpours at times that we cannot control major floods by simple land-use practices, and we as agricultural engineers must work with the Army and flood control engineers in control of major streams. There is demand for information and assistance in controlling the water in small streams which meander and destroy large areas of agricultural land annually. The storage of water in farm ponds and other impounding reservoirs is becoming an important part of the agricultural program. It is up to us to obtain information about water yields, runoff rates and peaks from our lands as part of the general water utilization and control program.

In the field of irrigation, actually only about 25 per cent of the total water supply goes into the root zone of the plants. Nearly 40 per cent of the water supply is lost in irrigation canals bringing it to and distributing it on the farm. The improvement of the efficiency of irrigation practices requires in-

vestigations of local conditions and much fundamental research. We have hardly touched the important problems of the timing of irrigation in various soils and under various climatic conditions. The engineer, however, has made notable progress in evaluation of water supplies stored as snow in high altitudes, and a good deal of our agriculture in the West is now guided by his forecasts. It should be understood that this is a vastly different problem from weather forecasting and is concerned with water supplies stored as snow in high places and in underground reservoirs. All of the water comes from precipitation, but the farmer needs to know how much usable water stored in these reservoirs he can depend upon.

Another important resource which must be constantly used or it is lost forever is solar energy. We take this for granted and have not fully evaluated it. It is obvious that in the growing season this energy is used by nature for the production of material useful as food and feedstuffs and the development of a protective mantle against erosion. We are commencing to appreciate the factor of length of day and intensity and kind of light on plant growth. We all know that chlorophyll, using mineral and other elements of the soil, water and solar energy, manufactures new material, taking, of course, oxygen and carbon from the air. If the manufacturing area of plants is grazed down below a certain limit, water and solar energy are lost. If the vegetative material produced is nót used, its greatest value may be lost with the decay process. The return of the unused residues may, however, be extremely useful in natural soil-building processes. It would seem only logical that we give adequate study and attention to this, the greatest source of agricultural energy, to determine how it can best be utilized.

ENERGY-WATER-PLANT FOOD COMPLEX

The energy-water-plant food complex forms the basis for adequate regulation of grazing. Cattle can graze only a limited distance from the water supply, so that the engineer, by making water supplies available over wider areas, permits the fullest utilization of this resource. At the same time he protects the soil resource. This concept applies equally to the utilization of the water resource or any element that is in limited quantity. It is a basic concept in land management.

Another great resource which the engineer has a major responsibility to maintain and develop is power. This is fundamentally the transfer of the potential energy of water to electrical energy and the transportation and application of this energy to the needs of industry and agriculture. When the water is allowed to run from the high places to the ocean, a certain amount of our power resource is lost forever. The engineer is largely responsible for utilizing power for creative work. The agricultural engineer is concerned both with large central plants and with the "little waters." Probably in total potential power the little waters equal if not exceed the great developments, which require large outlays of capital and for which there are only a limited number of suitable locations. We in agricultural engineering have not fully utilized the "little waters." We have been chiefly concerned during the last few decades with bringing the large power developments to serve the farmer. While this undoubtedly has been an economically sound course, there is still a great place for the smaller developments.

Rural electrification is of almost inestimable value to our agriculture. We have, however, barely scratched the surface of this development. It is within the power of rural electrification to revolutionize life on the farm and bring to it practically all of the conveniences of the city. Among these we can enumerate piped-in water, lights, fuel for cooking, and temperature control for man, animals, and farm products. Since electricity has come into general use more advance has been made in freeing the housewife from drudgery than was made in all the past thousands of years. Our Society needs to reemphasize the importance of this rural electrification work to get back the momentum we had attained before the war.

In advancing the use of electricity on the farm there is one very important consideration which we must not overlook. It is that we shall make the most rapid progress when the agricultural engineer is working in cooperation with various other specialists rather than attempting to work independently. In institutions and agencies, both federal and state, we as administrators are too apt to delegate the responsibility completely to the agricultural engineer and thus materially slow down the work. I ran into a good example of the teamwork that is necessary along this line in Alabama when I attended the meeting of the Southeast Section of the Society recently. There one of the main conservation problems was to get a good legume for soil building and cover. The agronomists were experimenting with blue lupine. They found that a great many of the blue lupine seed, because of their high water content, would not keep. As a result large quantities of the seed were lost. This became a critical point in the practical agricultural use of the plant. Agronomists and engineers from the station, power company, and steel company worked out with the farmer an experimental plan and tested it in a full-scale experimental plant. It looks now as though a valuable seed industry affecting a large section of the Deep South will result.

With all of the developments being made in agriculture, and especially since there was practically a cessation of building activity during the war, the agricultural engineer has a tremendous job ahead in the field of buildings. I do not wish to venture into prophecy, but I think we have reason to expect more progress in the field of farm structures during the coming generation than has been made in all times past. First, we have a wealth of new building materials, including the much-talked-about plastics and synthetic materials of various kinds. Second, the whole field of air conditioning, which was just getting well under way when the war started, may be expected to make rapid growth once wartime restrictions are removed. Basic experimental work being conducted by the Division of Farm Buildings and Rural Housing in the U.S. Department of Agriculture and at cooperating state agricultural experiment stations can be relied upon to give us some definite, specific information as to true housing requirements. The experiments in requirements of swine being conducted in California, of cattle in Missouri, and of poultry at Beltsville, Maryland, are particularly impressive. We have only recently begun to think of buildings as productive mechanisms rather than mere shelters and to incorporate equipment into these structures. I have in mind such items as fans, ducts, and other devices for hay curing, and equipment for the artificial lengthening of the day in poultry houses for greater egg production. There is a considerable list of such relatively new developments, but here again we have hardly scratched the surface in the line of progress.

COORDINATION AND INTEGRATION NEEDED

With knowledge which is constantly being increased by research developments, we are becoming conscious of the necessity for coordination and integration of the various specialties and agencies in order to get practical results for the farmer. The idea is an old one, but actual coordination is only now becoming effective. A great many scientific developments still proceed more or less independently when they could be speeded up through cooperation and coordination. The departments within the state institutions and the bureaus within the U. S. Department of Agriculture in the past have not been sufficiently coordinated. Such coordination is now being effected by the state colleges for their departments and by the Agricultural Research Administration for the bureaus within the Department of Agriculture.

Cooperation between the state and federal agencies and the farm equipment industry is still "hit and miss." In the work with farm machinery, the agricultural engineer has a definite responsibility. First, most modern agricultural practices require the use of equipment for their economic application. Second, in view of the complex conditions which vary throughout the country, such practices must be "pilot planted" and tested in the field before they can be applied over broad areas or extensive recommendations can be made. These field tests or "pilot plant" studies are especially important in that, if properly carried out, the time which would otherwise intervene between the finding of new information and its application to the farm is materially shortened. Mr. McAmis of the Tennessee Valley Authority once told me that if an extension worker, and he referred particularly to specialists, could travel around the state after ten years of work *(Continued on page 288)*

Heat Generated in Chopped Hay and Its Relation to the Drying Effect

By A. T. Hendrix
MEMBER A.S.A.E.

THE practice of drying hay in the mow by forced ventilation has been in use for several years. Varying degrees of success have been experienced by farmers over widely separated areas of the country. Several factors are involved in the process of mow hay drying, and various separate studies are currently under way to determine the relationships and effects of the various factors involved.

One of the factors which has received some consideration in mow hay drying has been that of heat generated in the hay during the drying process. In discussions of rates of drying it has been generally assumed that the moisture was removed under conditions of adiabatic drying. Under such conditions the air forced through the hay provides the heat for vaporization of moisture. While it has been generally recognized that heat was generated in a mass of undried hay, the quantity of such heat usually has been considered as of minor significance.

Numerous test observations of rates of hay drying have indicated that actual results obtained could not well be explained or computed on the basis of assumed adiabatic drying. Further observations indicated that consideration of the quantity of heat generated in the hay might be of value in reaching more satisfactory conclusions in relation to removal of moisture from hay in the mow. Consequently, a cooperative study between the Tennessee Valley Authority and the Tennessee Agricultural Experiment Station was planned to investigate this factor in mow hay drying.

Experimental Equipment and Procedure. Determination of heat released by hay during the mow-drying process requires rather careful and accurate measurements of volume of air flow, temperatures, relative humidity, and other related factors. To facilitate such measurements, a special installation was planned. The actual installation is shown in Fig. 1, and diagrammatically in Fig. 2. As shown in Fig. 2, the hay storage space was completely enclosed except for air supply and discharge ducts. Plenum chambers were constructed both below and above the hay. The floor was of slatted construction with approximately one-fourth of the floor area open for air entry into the hay.

Air was supplied by a forwardly-curved blade centrifugal fan operating at constant speed. This fan discharged into the lower plenum chamber through a short duct in which a gate was placed to regulate the volume of air flow. The volume of air supplied by the fan was determined by means of a calibrated orifice placed in the intake duct leading to fan. Air flow was checked periodically by pitot tube traverse of the duct. Air from the upper plenum chamber was discharged into the atmosphere through a short duct or discharge tube in which a relatively high velocity of flow was maintained. The upper chamber thus served the purpose of collecting and mixing the air after it had passed through the hay, and facilitated more accurate measurements of qualities of air leaving the hay.

Observations of static pressures were made in the lower plenum chamber, at selected points throughout the hay, and in the chamber over the hay. Wet and dry bulb temperatures were recorded at point of entry of air into the lower plenum chamber and also at point of exit of air from the upper chamber. These temperatures were recorded by a multiple-point micromax recorder and check readings were made hourly by calibrated wet and dry bulb thermometers.

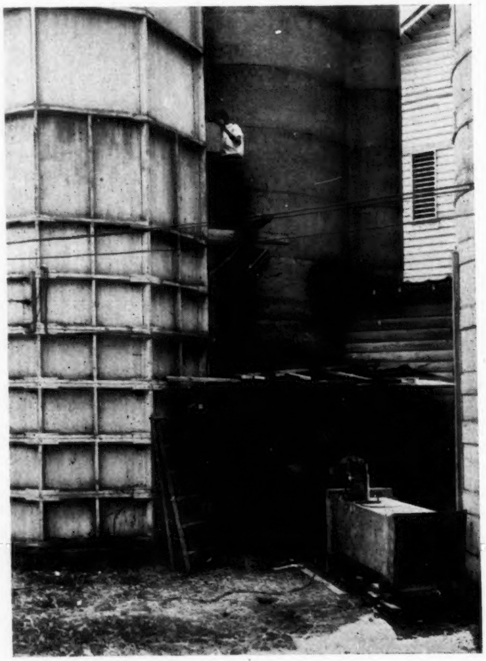

Fig. 1 Installation of experimental equipment to determine heat released during the mow-drying process

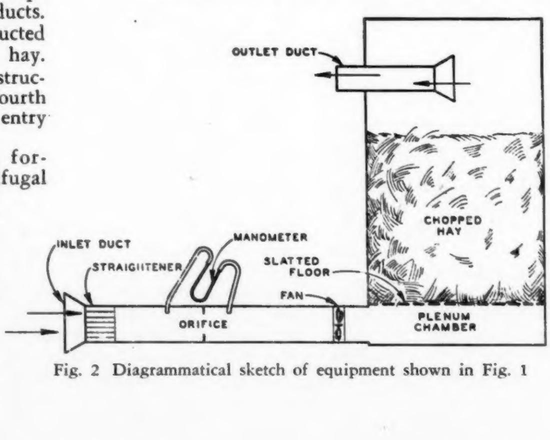

Fig. 2 Diagrammatical sketch of equipment shown in Fig. 1

The bin was octagonal in shape with 72 sq ft of floor area. Chopped hay of 39.3 per cent moisture content was loaded into the bin to a depth of 8½ ft. The weight of the hay was 5410 lb as placed in the bin. The nominal length of cut was 0.75 in. Air flow ranged from 24 to 28 cfm per sq ft of floor area during the test. The static pressure differential required to effect this rate of air flow ranged from 1.75 to 1.87 in.

The results obtained are shown graphically in Fig. 3, by reference to which it may be observed that heat was continuously added to the air as it passed through the hay. The rate at which heat was generated in the hay mass was greatest during the first part of the drying, and decreased as the moisture content of the hay was reduced. During the comparatively short drying period of 111 hr the mean moisture content of the hay was reduced to 14.1 per cent as sampled. It may be noted that although the rate of moisture removal had been lowered to zero value and below near the end of the test, some heat was being added to the air passing through the hay. The additional total heat of the air as shown by Fig. 3 includes the released energy of the air stream.

It was noted that 666,000 Btu of heat were added to the air-vapor mixture as it passed through the hay during 60 hr of night operation from 8:00 p.m. to 8:00 a.m. Also, 536,000 Btu of heat were

This paper was presented at the 3rd Barn Hay-Curing Conference sponsored by the American Society of Agricultural Engineers, at Chicago, Ill., December, 1946.

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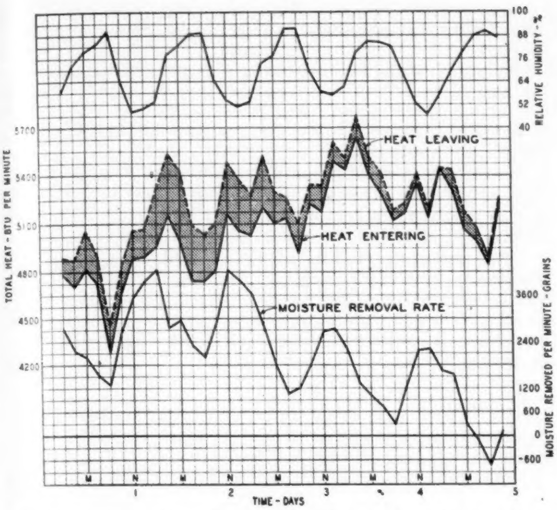

Fig. 3 This graph shows the heat released by chopped hay during the mow-drying process

added during 51 hr of daytime operation between 8:00 a.m. and 8:00 p.m. Thus a total of 1,202,000 Btu of heat were added to the air as it passed through the mass of hay. During these same periods, the total moisture removal was 694 lb during night operation and 1112 lb during the periods of day operations as computed by measurement of air conditions as air entered and left the hay. In practical engineering calculations the quantity of heat required to vaporize moisture at atmospheric pressure is constant. For each pound of moisture evaporated from this lot of hay approximately 1050 Btu of heat were required. During the periods of night operation the heat added—if utilized wholly in moisture evaporation—would account for removal of 635 lb of water. During the day periods the moisture removal due to heat would have been 510 lb. Thus during night operation the heat generated in the hay mass could account for 91 per cent of the moisture removed during that time, while only 46 per cent of the drying effect during the day period could be thus accounted for. For the entire drying period approximately 63 per cent of the heat necessary for drying was supplied by the heat generated in the hay due to respiration and other causes.

Adiabatic Drying. If the usual design assumption of air leaving the hay at 85 per cent relative humidity is used, the total drying capacity would have been 77 lb of moisture during the night periods and 698 lb during the day periods, a total adiabatic drying capacity of only 775 lb, whereas actually 1806 lb of moisture were removed from the hay.

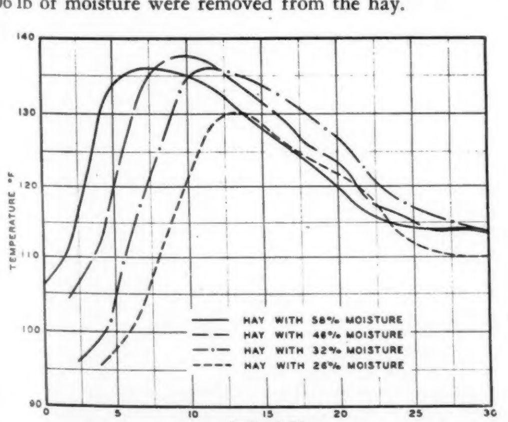

Fig. 4 The effect of moisture content on heating during mow-drying of hay (Test No. 1)

Again, if we assume that the air forced through the hay left at 100 per cent relative humidity during the entire drying period, the total drying capacity would have been 1467 lb of moisture as compared to the 1806 lb actually removed. Thus it appears that the heat generated in the hay constitutes a considerable if not a major factor in the drying process even under conditions of high rate of air flow and favorable drying conditions. As conditions for drying become less favorable, the effect of the heat thus supplied should be proportionally increased.

Rate of Temperature Rise As a Measure of Heat Generated in Hay. A second series of tests was conducted as a general check on the results indicated in the foregoing discussion. In this series several lots of hay were packed in insulated containers and the rate of temperature rise noted as a measure of the quantity of heat generated.

Two tests were conducted. In the first test four boxes 4x4x5 ft high were used. Each box was insulated with one inch of celotex board to reduce the heat loss to the ambient atmosphere. A quantity of 64 cu ft of hay packed in each box was computed on a basis of 20 per cent moisture and 450 cu ft per ton density. Alfalfa samples of different moisture contents were placed in the separate containers. When each container was filled, a thermocouple was inserted in the center of the hay mass and a cover was placed over the top. Temperatures were recorded by means of a micromax instrument.

A summary of the results of this test is given in Fig. 4, which shows that the rates of temperature rise during the first two hours of heating were lower than during the entire period of rise, and that the rate of rise did not greatly vary within the range of moisture contents shown. The maximum temperature reached in each of the three lots with highest moisture content differed by only one degree.

At the maximum temperatures shown, the enzymic action responsible for generation of respiratory heat was apparently destroyed and the temperature then subsided.

A second test of similar nature was conducted using two smaller containers. Two lots of hay of approximately equal moisture contents were placed in these boxes. Each lot of hay was permitted to increase in temperature and was then cooled before the temperature had reached a point at which the respiratory enzymes in plant material which are responsible for respiratory heat development are themselves destroyed. Moisture content of each lot was varied by partial drying and the lots were then permitted to again rise in temperature. This procedure was followed repeatedly as shown by Fig. 5.

The results are shown in Fig. 5. As indicated by this graph, the rate of temperature rise increased slightly as temperature increased, and the rate of rise was higher for the higher moisture contents. This characteristic was more pronounced as the moisture content approached that which is considered safe for storage. However, there was a definite increase in temperature even when the moisture content of the hay was considerably below 20 per cent. A measurable temperature rise was observed when the moisture content of the hay was as low as 13 per cent.

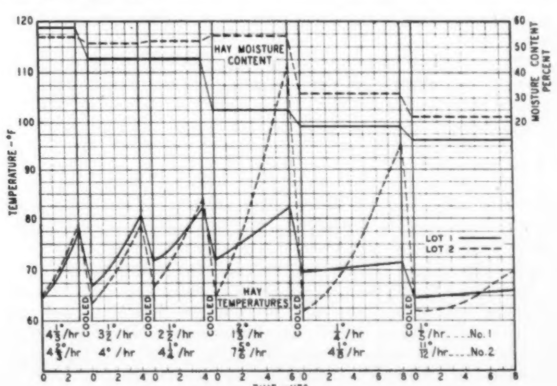

Fig. 5 The effect of moisture content on heating (Test No. 2)

Total Heat Generated in Hay. On the basis of temperature rise as obtained during these tests, it may be assumed that heat is continuously generated in a mass of tough hay unless the hay has been permitted to rise to a relatively high temperature and the enzymic action thus destroyed. As shown by these tests, the rate of temperature rise during the first two hours of heating in alfalfa hay of a moisture condition usually recommended for mow drying varied from 2F per hr to 5.5F per hr, with a mean value of about 3F. Using the lower value of 2F as a basis for computation, the total heat generated in a mass of hay may be estimated. Specific heat of tough hay is not constant but varies with moisture content. The value will probably vary between 0.45 and 0.65 (minimum values) for hay from 20 per cent to 50 per cent moisture contents, respectively. The mean specific heat of hay during drying would then be approximately 0.55 and the quantity of heat required to raise the temperature of 2000 lb of tough hay 1F per hr would be 2200 Btu per hr (variable), or 52,800 Btu per 24-hr day. This quantity of heat could account for the average removal of about 50 lb of water per day per ton of tough hay. Since only 750 lb of moisture must be removed from each ton of 50 per cent moisture content hay for safe storage, the quantity of heat indicated would be sufficient to remove 66 per cent of the required amount during a 10-day drying period.

For drying periods usually experienced in mow hay drying, the heat generated within the hay as indicated by this estimate might well account for a major part of the total moisture evaporated. During a period of from 7 to 14 days as is commonly experienced in mow hay drying, the total heat evolved may be of surprising proportions if the indications of these tests are accepted as true. Further studies should be of value in obtaining data to verify or disprove the indicated importance of this factor in mow hay drying practice.

Hay Drying as Affected by Respiratory Heat. The quantity of respiratory heat generated in tough hay may vary to a considerable extent. However, in all of our test observations and in observations of actual mow drying installations, the generation of heat has been very marked.

It has been the usual recommended practice in mow hay drying in the past to operate the fan continuously during the day and on an intermittent schedule during the night. Night operation was for the purpose of removing the heat within the hay, but it was commonly assumed that due to high relative humidity of the air (during the night period) the drying effect would be of negligible or even negative value. The temperature rise in the hay under this schedule of intermittent operation was sufficient to require fan operation on a schedule of one hour out of four during the night period to prevent overheating. Such operation apparently was the principal cause of condensation of moisture in the upper layers of hay, resulting in favorable conditions for mold formation.

Consideration of the respiratory heat factor in forced ventilation of drying hay in the mow, together with other considerations, indicated that there might well be some advantages in operating the fan on a continuous basis, at least during the first half of the drying period. Consequently studies were undertaken to observe the results obtained by fan operation 24 hr per day.

Experimental Equipment. The equipment for these studies consisted essentially of that described in the first of this discussion except that the bin was mounted on scales so that the weight of the contents could be determined at any time. Air flow was maintained for this study at 15 cfm per square foot of mow floor area.

The results obtained during two tests are shown by Fig. 6. The left side of graph shows characteristic mean daily moisture removal curves during the first half of the drying period with fan operation 24 hr per day. The right half shows corresponding curves for the last half of the drying period.

It will be noted from the data that the actual rate of moisture removal during the first part of the drying period was greater, especially at night, than would have been possible by adiabatic drying even though the air supplied had all passed through the hay and had left the hay at 85 per cent relative humidity. It may also be noted that, if the total air flow passed through the hay and emerged at a mean value of 85 per cent relative humidity during the entire test, it would not necessarily serve as a fair basis for computing the total moisture removal.

However, such assumptions are misleading since by far the greater portion of moisture was removed during the first half of the drying period. Regardless of the fact that the rate of moisture removal during the last half of the drying was much lower than during the first half, there were very few instances during which there was a net gain in weight of the hay. A sustained period of very high humidity would effect a gain in weight when operating on a 24-hr schedule during the entire drying process.

The results obtained by these and other tests indicate the desirability of continuous operation of the fan during the first half of the drying period. During the latter portion of the period, a schedule of intermittent operation or a lower rate of air flow on a continuous schedule might well be a more economical practice.

SUMMARY

The heat of respiration and bacterial action is an important factor in mow drying of hay. Sixty per cent or more of the heat necessary for vaporization of moisture from tough hay may be supplied from the hay due to respiratory and bacterial action during usual drying periods experienced in mow curing of hay.

Respiratory heat is continuously released by undried hay which has not been heated to the temperature at which respiratory action is destroyed.

In mow drying of tough hay under unfavorable weather conditions moisture will be removed due to heat generated in the hay.

Intermittent fan operation increases condensation in the upper layers of hay and promotes more favorable conditions for mold formation.

Continuous operation of the fan during the first part of the drying period is apparently justified. Economic considerations will determine whether or not the fan should be operated continuously during the last part of the drying period.

Ag Engineering in Reconversion Period

(Continued from page 285)

and see here and there a development which he had spearheaded, he could consider his work a great success.

We look forward confidently to closer cooperation among the research agencies of the state and federal governments, the industries which make and service the farm equipment, the educational institutions — particularly the extension service — which must blaze the way by education, and the service agencies which are directly assisting the farmer with his technical problems. All of these are integral parts of the agricultural organization which is necessary for a highly developed, civilized country and in which the agricultural engineer has a major responsibility.

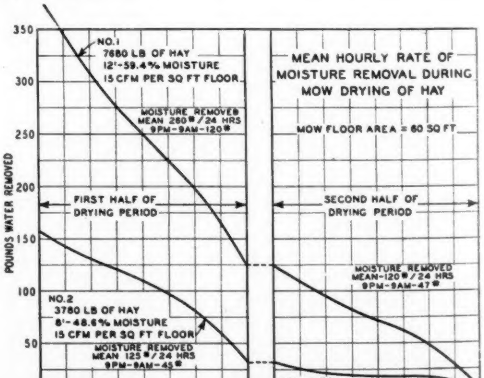

Fig. 6 Hay drying as affected by respiratory heat

Supplemental Heat in Mow Drying of Hay

By Roy B. Davis, Jr.

JUNIOR MEMBER A.S.A.E.

IT HAS long been recognized that the use of supplemental heat in forced-ventilation hay drying offers certain advantages and disadvantages. Possibly the major advantage is that the time required for mow drying is materially reduced since the moisture-removing capacity of the air is increased. This reduction in drying time would increase the quality of the hay produced and the capacity of the drying system. Another advantage is the feasibility of drying hay in the mow regardless of weather conditions, and elimination of the motor controls necessary to cut off the motor during periods of bad weather. The disadvantages of supplemental heat are increased fire hazard, more personal attention required unless the heating system is made automatic, and increased initial cost of the installation.

A study of weather conditions in several localities in Virginia showed that both early and late cuttings of alfalfa must be dried when long periods of high humidity prevail. Observations on the present system of hay drying showed that the required long-drying periods, when the humidity was high, sometimes resulted in spots of moldy hay.

With this background the Virginia Agricultural Experiment Station and the Farm Electrification Division (BPISAE), U. S. Department of Agriculture conducted several tests in 1946 in an effort to evaluate some of the advantages and disadvantages of supplemental heat. Tests were conducted in two experimental forced-ventilation drying bins so that the results obtained could be compared. The air used to dry the hay in one bin was preheated and that used in the other was not. Both bins were filled with the same amount of hay of comparable quality and moisture content for each test.

The bins were 8x8 ft with corners rounded on a 2-ft radius. Walls were 12 ft high and were smooth and airtight. Flooring was of 3-in slats placed 6 in on centers and supported by joists. The outer portion of the floor was covered so that only one-fourth of the total area was open for the air to enter the hay. These bins were mounted on recording scales and a continuous record of the weight of the hay was obtained. A plenum chamber was provided underneath each bin and was connected to the blower by an air supply duct. Each air supply duct contained honeycomb straighteners and an orifice station. Air flow was measured in the duct by an orifice and a differential pressure manometer. The blower was driven by an electric motor through a variable-speed, V-belt drive which provided adjustable blower speed to obtain desired air flow.

Air delivered by one of the blowers was preheated by a stoker-fired, hot-air furnace. Heating apparatus consisted of the furnace with stoker and a heat exchanger. Exhaust gases from the furnace were passed through a heat exchanger made up of 3-in galvanized pipes. Air was drawn into the heater around the pipes of the heat exchanger, then around the furnace, and on to the blower. Temperature of the heated air was controlled by a thermostat in the air stream. A second thermostat was located just above the furnace to stop the stoker if the air flow stopped. This thermostat protects the installation should the motor, belt, or blower fail.

Temperature and humidity were recorded by instruments located outside the air ducts, in the plenum chamber of each bin, and in a collecting duct on top of the hay in each bin. These recorders were checked frequently with hand-aspirated psychrometers.

Use of supplemental heat was observed in two comparative tests. First cutting alfalfa, cut in the one-tenth bloom stage, was used for the first test. The bins were filled to a depth of 12 ft with about four tons of hay of 58 to 60 per cent moisture content. When dry this hay had settled to a depth of 8 ft. Second cutting alfalfa was used for the second

This paper was presented at the 3rd Barn Hay-Curing Conference sponsored by the American Society of Agricultural Engineers, at Chicago, Ill., December, 1946. It is a progress report of cooperative research by the Virginia Agricultural Experiment Station and the farm electrification division (BPISAE), U. S. Department of Agriculture.

ROY B. DAVIS, JR., is assistant agricultural engineer, Virginia Agricultural Experiment Station.

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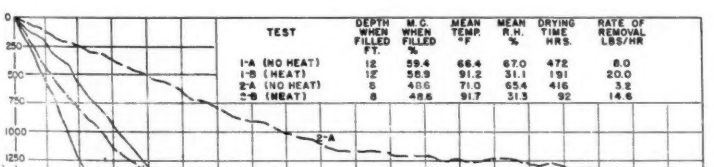

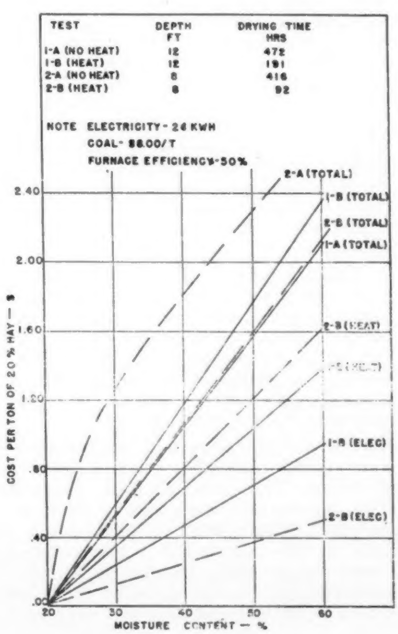

Fig. 1 *(Above)* Effect of supplementary heat on rate of drying long alfalfa hay • Fig. 2 *(Right)* Observations of cost of heat and electricity in drying long alfalfa hay

test. The hay was cut in the same stage of maturity and each bin was filled to a depth of 8 ft with about two tons of hay of 49 per cent moisture content. This hay was dried and during drying settled to a depth of 5 ft 9 in. The blowers were operated continuously during the drying in both tests and set to deliver 15 cfm per sq ft of floor area in each bin.

Using heated air, the bin containing the first cutting long alfalfa hay was dried from 59 to 20 per cent moisture in 191 hr. The temperature of air entering the hay was 91 F (degrees Fahrenheit) and the relative humidity, 31 per cent. To accomplish this drying 3820 lb of water was removed. During the same period the temperature of the air entering the bin with no supplemental heat was 65 F, and the relative humidity, 69 per cent. This air removed 2140 lb of water and reduced the average moisture content of the hay to 44 per cent. An additional 281 hr, or a total of 472 hr, was required to reduce the moisture content to 20 per cent. The mean temperature of the air entering the unheated bin for the entire drying was 66 F and the relative humidity, 67 per cent. This test shows that a temperature increase of 25 F and a relative humidity decrease of 34 per cent reduced the drying time from 472 to 191 hr, or 60 per cent.

In the second test the hay in the heated bin dried to 20 per cent moisture content in 92 hr. This required the removal of 1343 lb of water. The mean temperature of the air entering the bin was 92 F and the mean relative humidity, 31 per cent. The mean temperature of the air entering the unheated bin during this period was 69 F and the relative humidity was 72 per cent. This removed 470 lb of water and reduced the moisture content to 42 per cent. An additional 320 hr, or a total of 412 hr, was required to dry this hay to 20 per cent moisture. The mean temperature of air entering the hay in the unheated bin, during the entire drying period, was 71 F and the relative humidity, 65 per cent. Thus in this test, when the temperature of the air entering the hay was raised 21 F and the relative humidity reduced 34 per cent, the drying time was reduced 77 per cent. The rates of drying for the two tests are shown by the curves in Fig. 1.

COST OF SUPPLEMENTAL HEAT

When the use of supplemental heat is discussed, one of the first questions brought up is that of its cost. The operating costs of drying in these tests were computed on the basis of the cost of electricity at two cents per kilowatt-hour and coal at $8 per ton, with a furnace efficiency of 50 per cent. The cost of electricity to operate the blower in the first test with unheated air was $2.03 per ton of hay dried from 59 per cent moisture content to 20 per cent. When the air was heated an average of 25 F, the cost of electricity dropped to 95c per ton. However, the cost of heating the air was $1.43 per ton of hay dried, which made a total of $2.38, or 35c more than the operating costs when no supplemental heat was used. In the second test the cost of drying each ton of hay without heat from 48 to 20 per cent moisture was $2.24. With supplemental heat increasing the temperature of the air 21 F, the total operating cost dropped to $1.52 per ton. Of this cost, 36c was for power and $1.16 for fuel. In this test the hay dried with supplemental heat cost 72c per ton less than without heat.

The curves in Fig. 2 show the reduction in cost of drying as the moisture content of the hay decreased. It should be pointed out that the moisture content shown is the average for the bin of hay as computed from the moisture content and weight when stored and the loss of weight during the drying. The straight lines indicate that the rate of water removal decreases as the depth of hay to be dried and moisture content of the hay decrease.

The cost of drying with no supplemental heat in test 2 is shown as a curved line which is contrary to the form of the other tests. This curve, however, is practically straight on the upper portion and breaks downward at the point of 26 to 30 per cent moisture content. Observation of the drying rate curve for this test in Fig. 1 shows that the drying rate decreases sharply after nine days of drying. The average moisture content of the hay in the bin at that time was 27 per cent, and an additional nine days was required to reduce the moisture content to 20 per cent. This decrease in the rate of drying, which was reflected in the cost of drying, can be attributed to several days of rainy weather with periods of high humidity which caused the hay to absorb moisture from the air. If the drying in this bin had continued with only the normal decrease in rate of drying, the cost would have been much less and would probably show a straight line also. Under this assumption the cost of drying would have been slightly less with unheated air.

Under the conditions of these tests the cost of electricity for the blower, when supplemental heat was used, was about one-third of the total and the cost of heat, about two-thirds.

The operating cost relationship observed in these tests will vary considerably if different basic assumptions on the cost of electricity or coal, or a different furnace efficiency, are used. An increase in furnace efficiency from 50 to 75 per cent would lower the cost of heat to a point where it would be less than "no heat." On the other hand, a reduction in cost of electricity from 2 to 1½c per kw-hr would favor the practice of drying without supplemental heat.

The operating cost of the system using supplemental heat is only a part of the cost to be considered. The other part is the fixed cost created by the investment in heating equipment. Equipment will vary with each installation and will be determined by the size of the mow, rise in temperature of air desired, and fuel used. Size of the mow and rise in temperature desired will determine the size of the heating unit. Fuel to be used will determine the type of unit and the controls necessary for its safe and automatic operation. The tests showed that coal was burned at the rate of 2.75 lb per hr to raise the temperature of 900 cfm of air 21 F. This coal was rated at 14,000 Btu per lb. This meant that 38,500 Btu per hr were produced for the bin with a floor area of 60 sq ft. In other words, the furnace produced 30 Btu per hr per sq ft of floor area per degree rise with an air flow of 15 cfm per sq ft of floor area. In this instance the efficiency was about 50 per cent.

HEATING UNIT DOUBLES INVESTMENT

Experience with several systems in Virginia has shown that addition of a heating unit at least doubles the investment in the hay-drying installation. The systems have been coal or wood-burning boilers with steam radiation in which many of the parts were bought second hand. This additional investment cost of course increases the total cost of drying hay and will be a deterring factor in the widespread use of supplemental heat in Virginia.

An important consideration in the use of supplemental heat is its effect on the quality of hay produced. The grades of the samples taken from the various layers of hay in the bin are shown in Fig. 3. This chart shows the vertical relationship of the samples as they were *(Continued on page 293)*

DEPTH AS FILLED FT	TEST 1				TEST 2			
	GRADE		% GREEN COLOR		GRADE		% GREEN COLOR	
	HEAT	NO HEAT	HEAT	NO HEAT	HEAT	NO HEAT	HEAT	NO HEAT
10-12	SAMPLE LEAFY ALF LT GRASS MIXED (MOLDY)	SAMPLE ALFALFA (MOLDY)	50	55				
8-10	U S NO 2 LEAFY ALFALFA LT GRASS MIXED	SAMPLE ALFALFA LT GRASS MIXED (MOLDY)	45	50				
6-8	US NO 2 ALFALFA	SAMPLE ALFALFA LT GRASS MIXED (MOLDY)	50	40	U S NO 1 ALFALFA	US NO 1 ALFALFA	70	60
4-6	US NO 2 LEAFY ALFALFA	U S NO 2 ALFALFA LIGHT GRASS MIXED	55	40	US NO 1 ALFALFA	US NO 1 ALFALFA	70	65
2-4	US NO 1 ALFALFA	US NO 2 ALFALFA LIGHT GRASS MIXED	65	40	U S NO 1 ALFALFA	US NO 1 ALFALFA	70	60
0-2	US NO 1 ALFALFA	US NO 1 ALFALFA HEAVY GRASS MIXED	70	60	U S NO 1 ALFALFA	US NO 1 ALFALFA	65	60

Fig. 3 Observations of effect of supplemental heat on quality of long alfalfa hay

Better Quality Hay

By S. T. Dexter, W. H. Sheldon, and C. F. Huffman
MEMBER A.S.A.E.

THE dairyman and the animal feeder continually demand better hay. Programs for the control of soil erosion and the maintenance of high soil productivity demand more and better hay. For more than 10 years, cooperative experiments at Michigan Agricultural Experiment Station have shown that hays vary greatly in yield, ease of curing, and feeding value.

The approach to the problem of better quality hay may be from any one of three directions. The farmer may put the land into such condition that he is able to grow inherently good legume hays. Hays such as alfalfa don't just grow, like Topsy; the farmer has to raise them. Or, the farmer may fertilize his grass hays and cut them at earlier stages of maturity. If these grass hays can be cured, they may equal or surpass ordinary legume hays in feeding value. Table 1 shows how the yield and quality of a grass hay can be improved by a simple fertilizing and management practice. In the third place, by improved curing practices the farmer may attempt to save a maximum of the feeding value in his hay.

The management of the good legume hays has been studied and described in considerable detail. Usually it is impracticable for farmers in the Middle West to cut their alfalfa or clover at the very early stages when the feeding value is at a maximum. Such a practice lowers the yield of hay and weakens the plants, leading to weedy, short-lived stands. Nor is the production of highly nutritious hays from grasses such as timothy as simple a matter as it might appear. Although it is easy to increase the yields at relatively low expense, the early-cut, high protein and low-fiber hays are difficult to cure. Early cutting brings hay-making into a season characterized by cool weather and frequent showers. The early-cut hays, whether of legume or grass, are low in fiber and high in protein. The stems lack stiffness, the hay packs into soggy lumps, and is more hygroscopic than are ordinary hays. A previous paper[3*] has described the vapor pressure characteristics of alfalfa hay at various moisture contents. For example, at 80 per cent RH (relative humidity) an immature bromegrass hay came to a moisture content of 20.6 per cent, and an overmature hay, 12 per cent. Thus these immature hays are inherently hard to cure even in good weather.

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S. T. DEXTER is research associate in farm crops, W. H. SHELDON is research assistant in agricultural engineering, and C. F. HUFFMAN is research professor in dairying, Michigan Agricultural Experiment Station.

*Superscript numbers refer to appended references.

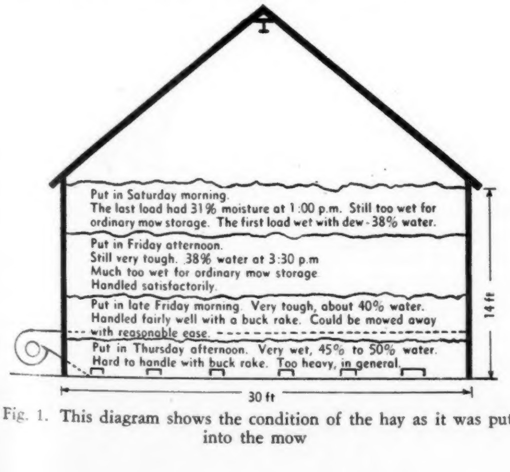


Fig. 1. This diagram shows the condition of the hay as it was put into the mow

TABLE 1. THE AVERAGE YIELD IN POUNDS PER ACRE OF GRASS HAY AND OF PROTEIN FROM OLD MEADOWS IN 10 COUNTIES OVER A PERIOD OF THREE YEARS

(The fertilized plots received 200 lb of ammonium sulphate per acre)

	Fertilized, early cutting date			Unfertilized, ordinary cutting date		
	Hay per acre, lb	Protein, per cent	Protein per acre lb	Hay per acre, lb	Protein, per cent	Protein per acre, lb
1936	2688	11.05	297	1927	7.11	137
1937	2707	9.72	263	1741	5.15	90
1938	3612	10.38	377	3070	6.81	207
Ave.	3002	10.39	312	2249	6.00	145

Extensive efforts have been made to cure these hays because of their peculiarly high feeding value for milk production. The methods thus far suggested appear to be too cumbersome for acceptance in large-scale production[4]. Yet the problem remains one of our most important ones. In many regions our agricultural land is carrying too much grain. Many fields should carry sod crops most or all of the time. Yet a feeder needs grain, or something the equivalent of grain, to supplement low-quality hay, if he is to get reasonably good production of milk or meat. Feeding tests at Michigan State College have demonstrated that many of our early-cut hays have milk-producing capacities, when supplementing ordinary hay, almost the equal of grain. Table 2 gives an indication of the value of such hays. Furthermore, such early-cut, fertilized hay may, on the average, yield double the total digestible nutrients per acre that a small grain would yield on the same land, and with no danger of damage from soil erosion.

The problem of curing hay, of whatever stage of maturity, is by no means a simple one. Respiration goes on continually in living cells. When photosynthesis stops, the enzyme systems that use up starches and sugar continue to operate and set free carbon dioxide. Heat is generated in these respiratory processes. In the mow a high relative humidity of the air encourages the growth of molds, which in turn greatly increase the loss of carbon dioxide and decrease the feeding value of the hay. It would appear that, if we leave the hay in the field too long we lose the leaves, while if we bring it in too soon, and cure it slowly, we lose the sugars[1]. Similar problems exist so far as vitamins are concerned.

TABLE 2. EARLY GRASS HAY COMPARED WITH ORDINARY ALFALFA HAY FOR MILK PRODUCTION

Cow No.	Days in milk	Average daily milk*, lb: Ordinary alfalfa	Average daily milk*, lb: Early-cut grass hay	Per cent change in milk production	Remarks
A5	216	14.9	19.9	33.6	1941 tim. Boot stage
A30	99	14.8	20.7	39.9	"
A5	252	14.9	18.3	22.8	1942 early heads
D14	174	12.9	15.9	23.3	" " "
267	203	13.5	16.9	25.2	" " "
267	259	15.6	17.4	11.2	9 lb early cut wheat hay replaced 12 lb alfalfa
267	286	15.6	18.3	17.3	15 lb early cut wheat hay replaced 18 lb alfalfa

*4 per cent fat corrected milk.

In general, the feeding value of a hay is limited by the characteristics of the material that passes over the cutting bar. In many hays there is but little potential feeding value. A material high in lignified fiber and low in protein will not be converted into an excellent or even a fair hay merely by blowing through it, and the farmer can afford to spend but little on it. Yet, in theory, a superior curing practice should save more feeding value than a poor practice, regardless of the initial value, and it has sometimes been assumed that the feeding value of mow-cured hay would be superior to that of other hay.

In order to test the actual merit of the mow drier in producing a hay of superior feeding value, and to test the merits of different methods of mow-drying, feeding trials were conducted with dairy cattle at the Michigan Agricultural Experiment Station.

The First Feeding Trial. In June, 1944, about 15 tons of mixed brome grass and alfalfa were put on a mow-drying system[2]. Fig. 1 shows the condition in which the hay was hauled. In the late summer, a trench was cut from top to bottom through the hay and samples were taken. The hay in the upper two feet was slightly musty and slightly discolored, while the hay in the bottom and middle layers was bright and green. Analyses for sugar and starches indicated that these had decreased as curing time increased, either in the field or in the mow. Thus the sugar content of the hay progressively decreased from bottom to top.

The hay from this mow was baled into three lots — the top third, the middle third, and the lower third — and was fed to 10 dairy cows as follows: In one experiment, with four cows, hay constituted the entire ration; with three additional cows, corn grain was fed in addition to the hay; and with three more cows, corn silage supplemented the hay. Uniform U. S. No. 1 field-baled clover and alfalfa hay was used in the control rations.

TABLE 3. AVERAGE DAILY MILK PRODUCTION PER COW FOR 4 COWS FOR CONSECUTIVE 15 DAY PERIODS WITH THE HAY RATIONS AS SHOWN
(Hay constituted the entire ration)

Weight of cow lb	Average daily milk* Produced, lb	Average daily milk* Decreased, lb	Hay eaten, lb	Remarks
1059	19.30		31.98	Control hay
		3.08		
1071	16.22		31.98	*Top* mow-cured
		0.97		
1097	15.25		31.88	*Middle* "
		1.33		
1093	13.92		31.18	*Bottom* "
		1.94		
1084	11.98		31.72	*Control* "
	Total,	7.32		

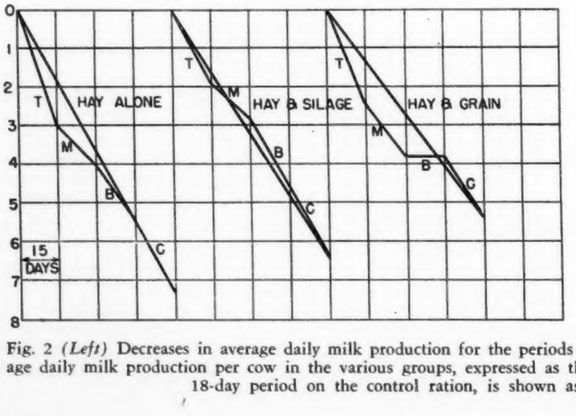
*4 per cent fat corrected milk.

In each cow's ration, ***top*** mow-cured hay was substituted for ***control*** hay, then ***middle*** hay for ***top***, then ***bottom*** hay for ***middle***, and finally, ***control*** hay for ***bottom***. Each hay was fed for a 15-day period. Table 3 shows the combined data for the four cows on a ration of hay alone. The table gives the average daily milk production as "4 per cent fat-corrected milk", the average weight of the cow, and the average amount of hay eaten daily, for each period. Corresponding tables for cows on rations with grain and with corn silage are omitted but the results are shown in Fig. 2. The total drop in milk production per day, due to advance in lactation, is indicated by the straight lines in Fig. 2, and the portions of the decrease due to the substitutions of the various hays are indicated by periods.

When expressed in this way, the top hay is never found to be as good as the control, while the *control* hay is never as good as either *middle* or the *bottom* hays. While the differences are not particularly large, there are indications that the slow curing (400 hr of fan operation) of the top layer was disadvantageous, even though no conspicuously moldy spots occurred.

Second Feeding Trial. In 1946 a second feeding experiment with mow dried hay was run. In this case, on an area of about 25 acres, every third windrow was taken into a mow drier to a depth of about 10 ft and at an average moisture content of about 31 per cent. It was cured without difficulty. The next third of the hay was picked up after curing in the field, and was put in the mow at an average moisture content of about 19 per cent. It cured without apparent heating or mustiness. The last third of the hay was permitted to lie in the windrow for 16 days. There was no rain during this period, but the hay became somewhat bleached. The windrows were tipped over with the rake before being baled from the field. In the same field, another area was cut promptly after this 25 acres and was made into hay, baling from the field. This hay was used as the control hay. No rain fell on any of the hay.

In the feeding experiment, one group of cows was fed the



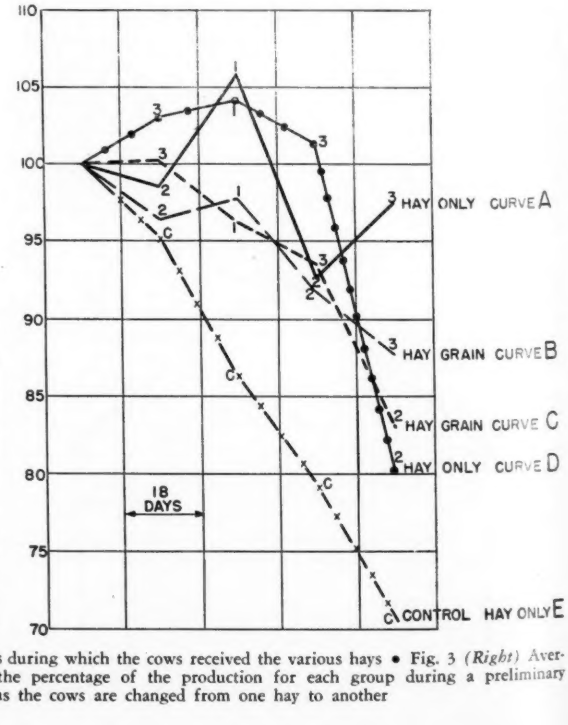


Fig. 2 *(Left)* Decreases in average daily milk production for the periods during which the cows received the various hays • Fig. 3 *(Right)* Average daily milk production per cow in the various groups, expressed as the percentage of the production for each group during a preliminary 18-day period on the control ration, is shown as the cows are changed from one hay to another

control hay only for the entire period. In the rations of four other groups of cows — two groups on hay alone and two on a hay and grain ration — the three experimental hays were substituted for 18-day periods, keeping the total weight of hay consumed the same throughout. In Table 4 are shown the average values for daily milk production for all five groups of cows. Fig. 3 shows these data graphically. For convenience, the mow-dried hay is called hay No. 1; the field cured, No. 2; the 16 days curing, No. 3; and the control, C.

TABLE 4. THE AVERAGE DAILY MILK PRODUCTION PER COW FOR GROUPS OF 3 COWS EACH, FOR THE PERIOD OF 18 DAYS, DURING WHICH THEY WERE FED THE VARIOUS HAYS

(Hays substituted in the order shown)

Hay fed, 18-day periods		Ration of hay alone: Average daily milk production, Pounds	Per cent	Ration of hay and grain: Average daily milk production, Pounds	Per cent
Control hay	(c)	18.5	100	34.3	100
Field-cured, 16 days	(3)	19.1	103.2	34.2	100.3
Mow-cured	(1)	19.3	104.3	33.0	96.2
Field-cured, 16 days	(3)	18.8	101.6	32.0	93.3
Field-cured, ordinary	(2)	14.9	80.5	28.5	83.1
Control hay	(c)	16.3	100	33.1	100
Field-cured, ordinary	(2)	16.1	98.8	31.9	96.4
Mow-cured	(1)	17.3	106.1	32.4	97.9
Field-cured, ordinary	(2)	15.1	92.6	30.4	91.8
Field-cured, 16 days	(3)	15.9	97.5	29.1	87.9
Control hay	(c)	21.6	100		
Control hay	(c)	20.6	95.4		
Control hay	(c)	18.7	86.6		
Control hay	(c)	17.1	79.2		
Control hay	(c)	15.2	70.4		

Production of the cows in the group on control hay alone falls off in a regular manner as the lactation period advances. This is typical in such an experiment. In curve A, substitution of hay No. 3 in the second feeding period gave a material increase in production; substitution of hay No. 1 for hay No. 3 gave a still further increase in production; a resubstitution of hay No. 3 for hay No. 1 gave a moderate falling off in production, although by no means as great as the control group, for the same period. Final substiution of hay No. 2 for hay No. 3 gave a notable decrease in production. In curve B, substitution of hay No. 2 for the control gave a decrease in production slightly less than that found in the control group; substitution of hay No. 1 for hay No. 2 gave a prominent change in the direction of the curve, with improved production; resubstitution of hay No. 1 by hay No. 2 gave a sharp decrease in production, approximately paralleling the control curve; and final use of hay No. 3 gave a sharp upward trend to the curve. In all cases, production on hay No. 2 seems definitely inferior, with hay No. 1 somewhat superior to hay No. 3. In curves C and D, where grain was fed rather liberally, the same trends are observable, although not as prominent. Since hay furnishes only one-half or two-thirds of the digestible nutrients in the rations, differences due to hay are less pronounced. This result is typical of such feeding experiments.

Total digestible nutrients and digestible protein were not limiting factors in these experiments, since all cows except one in these experiments received more total digestible nutrients and digestible protein than was required. They maintained their weight. Unknown lactation factors, beyond vitamins, sugars, fats, proteins, etc., are needed to make a ration efficient for milk production. Conservation of these factors appears to have been better in hays Nos. 1 and 3 than in hay No. 2.

SUMMARY

1 A program for better hay demands better hay species, better fertilization and cutting practices, even on poorer species, and better curing.

2 The quality of the cured hay can be no higher than the quality of the material that passes over the mower cutter bar.

3 Immature hays are difficult to cure, but may have high feeding values.

4 From feeding trials with mow-cured and other hay, the conclusion is reached that hay quality is best preserved by rapid drying in the mow or in the field, and that protracted drying is detrimental, even though no mustiness occurs.

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Supplemental Heat

(Continued from page 290)

dried. Samples taken from the top 6 ft of hay dried with unheated air in test 1 were graded "moldy" and the use of supplemental heat reduced the depth of moldy hay to 2 ft. In the bottom of the bin the use of heat increased the depth of hay graded "U. S. No. 1" from 2 to 4 ft. The average grade of the hay dried with supplemental heat in test 1 was about one-half grade higher than that dried without supplemental heat. On the basis of nominal quotations from the Kansas City market for November, 1946, this amounted to an increase in market value of about $5 per ton. The samples of the hay dried in test 2 were all graded as "U. S. No. 1" which means the use of supplemental heat failed to show as marked an advantage in this case.

Of the factors used to determine the grade, leafiness of the alfalfa, green color, and foreign material, only the green color was observed to vary with any consistency. The loss of green color was found to be greater when the hay was dried without supplemental heat. In each test the hay dried with supplemental heat had 8 per cent more green color than that dried without. When this increase in green color is evaluated for test 2, an increase in value of about 75c per ton may be attributed to the use of heat.

The carotene analysis of the samples of hay showed that the carotene content of the hay dried with supplemental heat averaged 88 micrograms per gram of hay and that dried without supplemental heat was 47 micrograms per gram. This gives an increase in the carotene content of 87 per cent where supplemental heat was used.

SUMMARY

The results reported in these tests cannot be treated as conclusions but only as limited observations. Further investigations are needed to substantiate or modify them. Some of the major points observed in these comparative tests are as follows:

1 An increase in the temperature of the air entering the hay of about 25 F by use of supplemental heat reduces the time required to dry the hay about two-thirds.

2 Operating cost of drying each ton of hay was only a few cents more when heat was used and the weather was good for drying without heat. When a period of rainy weather was encountered, the cost of drying without supplemental heat was increased substantially.

3 Total cost of drying was increased when supplemental heat was used, since the additional equipment increased the initial investment.

4 Use of supplemental heat increases the quality of the hay by reducing the time of drying and thereby reducing the growth of mold and loss of green color and carotene.

The Status Quo of Barn Hay Drying

By F. W. Duffee
FELLOW A.S.A.E.

A SYSTEMATIC breakdown of the results of mow hay-drying research was made at the beginning of the conference of research workers held at Chicago, December, 19, 1946. This was slightly different than the organization of two years ago. The present organization, including state agricultural experimental stations and the TVA (Tennessee Valley Authority) which are studying the various phases of hay drying, is as follows:

1 System design for (a) long hay—Pennsylvania, Virginia, TVA; (b) chopped hay—Oregon, Pennsylvania, Virginia, TVA, Wisconsin; (c) baled hay—Virginia, TVA, Maryland.
2 Density studies — New York, Virginia, TVA, Wisconsin, Maryland.
3 Resistance to air flow — New York, Pennsylvania, Virginia, TVA, Wisconsin, Maryland.
4 Palatability studies — New York, Indiana, Oregon.
5 Molds and bacteria — New York.
6 Supplemental heat — Oregon, New York, Pennsylvania, Virginia, TVA, Wisconsin, Maryland.
7 Economic studies (comparative costs of field and mow drying) — New York, Maryland, Pennsylvania.
8 Grading — Virginia, TVA, New York.
9 Respiratory heat — TVA.

The general trend of thought and experience reported by those present, on some of these specific subjects, may be summarized about as follows:

System Design. In addition to present designs of driers installed in barns, some thought is being given to the design of a separate suitably designed structure and drier to be used as a batch drier — the dried hay to be transferred to the barn proper by means of an elevator.

Another thought is that barn drying is an emergency proposition and will not be used for all the crop every year; therefore, it is suggested that only about one-half of the barn floor be equipped with a drier. During unfavorable years, the hay processed on the drier will then have to be moved over into another portion of the barn before putting another batch onto the drier section. Locality, climate, and viewpoint on use all influence design.

Considerable enthusiasm was shown for the round silo-like drier with the self-feeder principle.

The specific troublesome problems are as follows:

1 The narrow (20-ft) hay barn
2 The wide, high (32 to 36-ft) hay barn
3 A barn with a driveway through it
4 Extreme variations in density due to a variety of influences.

Density. This will always be a widely variable resultant of such variable contributing factors as the type of hay crop, its state of maturity, its coarseness of growth, its moisture content at time of storage, method of storage, and depth in the bin. There was some indication that cutting hay to 9-in lengths tends to minimize density variations within the drier for any one loading.

Resistance to Air Flow. In general, provision of air circulation in excess of 15 cfm per sq ft of floor area, in any appreciable depth of hay, involves problems of high power requirement.

Resistance to air flow is generally greater, and distribution is harder to control in chopped hay than in long hay. Longer lengths of cut help reduce air resistance. Probably better cutter and blower design to handle the cut hay more gently would decrease its resistance to air circulation and favor more uniform circulation.

Palatability. This is not primarily an engineering matter, although it may be influenced by hay handling and drying procedure. It may be desirable to work with animal nutrition specialists with a view to defining palatability values and factors, and determining the influence thereon of handling and drying methods.

Molds and Bacteria. Barn drying generally starts in a moisture and temperature range favorable for rapid mold and bacteria development. Rapid reduction of moisture content, at temperatures either above or below those most favorable for incubation of mold and bacteria, is desirable to limit their deteriorating effects.

Supplemental Heat. It is recommended that this be used only as and when necessary to expedite drying. This will vary throughout the country, depending on climate, from none to 100 per cent of the drying time. Sources of heat include waste heat of the engine used to drive the fan, and separate heating plants. Heating plants usually involve fire hazards which can be held to reasonable limits only at added cost. In the Southeast and other high-humidity areas supplemental heat is considered a necessary evil, to be developed to minimize its disadvantages. Internal-combustion engines have advantages over electric motors for blower power in being able to increase air circulation as an alternative to supplemental heat, and in furnishing considerable amounts of supplemental heat incidental to their operation.

Economic Studies. Any current data may quickly become obsolete. An over-all program must be properly developed and mechanized before any serious attempt can be made to determine over-all costs. Economic studies must also consider the relative merits of alternative ways of utilizing forage crops, including pasture, soiling, field drying of hay, and handling as grass silage. Extending the pasture season and providing reserve grass silage capacity tend to reduce the quantity and quality requirements for hay, and to permit greater flexibility in feed harvesting and storage. Individual cost items are significant guides to further engineering development. Availability or lack of labor and equipment are important considerations to the individual farmer faced with the immediate problem of how to handle his hay under existing circumstances.

Grading and Respiratory Heat. None of the research workers present at the conference had any comments to record on these subjects.

Management of Drier. Field drying of hay to 35 to 40 per cent moisture, whenever weather conditions are favorable, was generally recommended. The mow drier can then be used to best advantage to complete the drying with minimum delay, cost, and loss of hay quality. There was considerable controversy on this point, some holding that loss of leaves is serious in field handling of hay at 40 per cent moisture or less.

Research Needs, Equipment, and Techniques. Several items on this subject were thrown into the discussion for what they might be worth to others.

Curing in deep mows and flow of air through hay were mentioned as demanding further research.

Injection of smoke is one technique being used as a visual indication of air movement through hay.

(Continued on page 296)

This is a report of a special conference of research workers engaged in barn hay-drying studies held during the 3rd Barn Hay-Curing Conference sponsored by the American Society of Agricultural Engineers at Chicago, December, 1946. The research workers attending the conference were as follows: H. D. Bruhn, University of Wisconsin; R. J. Bugbee, Central Vermont Public Service Corp.; G. J. Burkhardt, University of Maryland; A. W. Clyde, Pennsylvania State College; F. W. Duffee, University of Wisconsin; R. W. Davis, Jr., U. S. Department of Agriculture; E. W. Hamilton, Allis-Chalmers Mfg. Co.; A. T. Hendrix, Tennessee Valley Authority; T. E. Hienton, U. S. Department of Agriculture; A. D. Longhouse, West Virginia University; G. E. Page, Purdue University; F. E. Price, Oregon State College; J. A. Schaller, Tennessee Valley Authority; J. B. Stere, West Penn Power Co.; C. W. Terry, Cornell University; G. E. Zerfoss, Tennessee Valley Authority.

F. W. DUFFEE is professor and chairman of the agricultural engineering department, University of Wisconsin.

Equilibrium Moisture Content of Alfalfa Hay

By S. T. Dexter, W. H. Sheldon, and Dorothy I. Waldron
MEMBER A.S.A.E.

IN THE operation of a mow hay drier, air at various relative humidities is blown through hay with various moisture contents. In this experiment, determinations were made of the moisture content of alfalfa hay at equilibrium with air having various relative humidities. Such values indicate whether partly cured hay will take up or lose moisture in any given atmosphere, and furnish a basis for mow-drier operation.

The literature on this particular subject is limited, although a number of papers have appeared on closely related subjects. Papers by Bailey[1]*, Wilson[9], Wilson and Fuwa[10], Coleman[2], Fairbanks[3] and others describe the humidity equilibrium of wheat, flour, flaxseed, and various other common substances. In recent papers, by Snow et al[5,6,7,8], the emphasis has been particularly on the problem of mold formation and the rate of respiration as a function of the moisture content of the feed and the relative humidity of the atmosphere. Briefly, these papers show that the moisture content of many materials at equilibrium is a function of the relative humidity of the surrounding atmosphere.

With most feeding stuffs, molding becomes notable, even in short periods of storage, at relative humidities higher than 85 per cent. Snow states that the mold growth was primarily a function of the relative humidity. More water is held in equilibrium at lower storage temperatures than at higher, although the differences are small. Snow[6] presents curves showing the moisture content—relative humidity equilibrium and spoilage rates for starch, protein, and fiber and their mixtures. These are particularly instructive when considering the probable characteristics of various kinds of hay or other feed. Snow[5] also presents figures on the molding of dried grass, giving the number of days at various humidities that elapsed before the first appearance of mold mycelia. In general, feeds that contained any considerable quantity of protein could not be stored for long periods at a relative humidity higher that 70 per cent without mold. Jennings[4] in blowing air through weighed samples of alfalfa hay found water absorption at night only in hay samples that were below an average moisture content of 13 per cent.

This paper was presented in part (by Mr. Sheldon) at the 2nd Barn Hay-Curing Conference sponsored by the American Society of Agricultural Engineers at Lafayette, Ind., January, 1946. It has been approved as Paper No. 825 N.S. of the Michigan Agricultural Experiment Station.

S. T. DEXTER, W. H. SHELDON, and DOROTHY I. WALDRON are, respectively, associate professor of farm crops, assistant professor of agricultural engineering, and assistant research professor of agricultural chemistry, Michigan State College.

*Superscript numbers refer to appended references.

Experimental Method. Suitable concentrations of sulphuric acid in water were prepared and stored in tight glass containers, partially filled with solution, so that the contained atmospheres were at chosen relative humidities. For the specifications of these solutions see Int. Crit. Tables, vol. 3, page 302, or Lange Handbook, page 1583, or Wilson[9]. These glass containers were stored in the open laboratory, tests 1 to 4, but in later tests (5 to 7) in a tight wooden box, to avoid unusual temperature fluctuations and consequent condensation on the glass and samples. The variation in room temperatures was about 4F throughout the duration of the later experiments, and probably less than that in the box. Several samples of dried hay, green hay, dried stems, and dried leaves were stored at these relaive humidities until virtual equilibrium was attained. This required from 10 to 30 days.

In samples at the higher humidities, molding was always extreme and complete equilibrium could not be attained, since the samples lost weight after mold had developed, presumably by respiration. Samples were weighed to 0.0001 gram. Samples in tests 1 to 4 had a dry matter weight of approximately 0.2 gram; samples in tests 5, 6, and 7 from 2 to 8 grams.

Description of Samples.

1 Alfalfa hay, 1944, young first cutting, barn-dried for 6 months before exposing in the humidity jars.

2 Alfalfa hay, 1944, woody second cutting, barn-dried for 5 months before exposing in the jars.

TABLE 1. MOISTURE CONTENT OF ALFALFA HAY, IN PER CENT BY WEIGHT, AFTER EXPOSURE TO AIR OF VARIOUS RELATIVE HUMIDITIES, IN PER CENT

R.H. Test No.	0	5	20	25	40	50	60	65	70	75	80	85	90	95	100
1	5.3		10.2		11.7		12.0				17.8		20.7*		39.4†
2	2.7		5.7		8.5		10.6				14.9		18.4*		32.0†
3	4.3		7.4		9.8	10.6	12.8		15.7		18.6*		36.8†		78.4†
4	3.2		6.4		9.4		13.3				19.0*		23.5†		65.0†
5		4.25		6.51		9.37		11.45	12.51	13.96	15.76	18.41	21.73*	24.63*	28.56†
6		5.36		7.48		10.43		12.72	13.81	15 56	17.47	20.88	24.87*	29.56*	37.47†
7		5.21		6.90		10.14		14.24	16.50	19.50	23.13	26.62*	57.31*	67.19†	79.00†

*Moldy. †Very moldy.

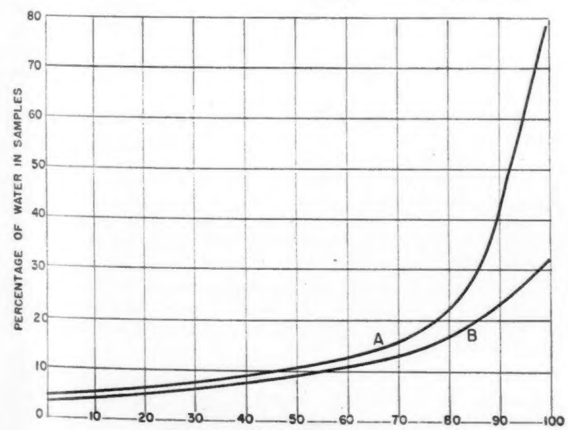

Fig. 1 Equilibrium moisture content of alfalfa: Curve A, average of freshly harvested samples (tests 3 and 7). Curve B, average of barn-dried samples (tests 1, 2, 5, and 6)

3 Freshly harvested alfalfa from greenhouse, somewhat immature, exposed in undried condition (1945).

4 Same as 3, but dehydrated over concentrated sulphuric acid before exposing in the jars.

5 Alfalfa hay, 1945, first cutting stems, barn-dried for 6 months.

6 Leaves from alfalfa hay, 1945, first cutting, barn-dried.

7 Freshly harvested alfalfa, somewhat immature, exposed in undried condition (1946).

Experimental Data. Table 1 presents the figures for the equilibriums in the seven samples. Curve A in Fig. 1 shows in graphic form the composite data from samples in tests 3 and 7. Curve B shows the results from the four tests with barn-dried samples. Fig. 2 shows the apparatus with which the samples in tests 5, 6, and 7 were exposed to the various atmospheres. Samples in tests 1 to 4 were exposed in large test tubes. It will be observed that the data for the freshly harvested samples in tests 3 and 7 are similar.

Discussion. At high relative humidities all samples, particularly those which were freshly harvested, became masses of mold, and the data represent to a considerable degree the moisture content of molds rather than of hay at those relative humidities. In test 1 (early-cut first cutting), tests 3, 4, and 7

Fig. 2 Containers used for samples in tests 5, 6, and 7

(immature), and test 6 (leaves), the samples were all high in protein and showed the characteristic high moisture contents at high relative humidities that Snow[6] described. Wright[11] described the spoiling of dried grass (high in protein) when stored at relatively high humidities in England. When the stems in test 5 and the leaves in test 6 are compared, one can observe that, particularly at high relative humidities, the leaves (high in protein) absorbed more moisture.

When the partially dried samples, in tests 3 and 7, were exposed to an atmosphere with a relative humidity of 85 per cent or higher, drying did not proceed to a point at which even short storage was possible without molding. At 80 per cent relative humidity, however, an equilibrium was reached at which molding was materially retarded. At any such relative humidity, however, the effective vapor pressure deficit would be exceedingly slight for hay as moist as that ordinarily placed in mow driers, and the main function of the air blown through would then be to prevent undue heating.

SUMMARY

Samples of alfalfa hay, both dried and undried, were exposed to atmospheres of various relative humidities until an equilibrium of moisture content was attained. In general, molding occurred at relative humidities of 85 per cent or higher within a period of one or two weeks. Samples high in protein appeared to absorb moisture more at high relative humidities than did samples lower in protein. Freshly harvested samples with cells still living maintained a far higher moisture content and molded more readily at high relative humidities than did samples dried before such exposure to high humidity.

Barn-dried alfalfa did not absorb moisture from air with a relative humidity of 80 per cent, unless the moisture content of the hay was below 15 per cent which is considered dry enough to keep in ordinary storage.

Barn-dried alfalfa did not absorb moisture from air with a relative humidity of 90 per cent unless the moisture content of the hay was below 20 per cent.

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Status Quo of Barn Hay Drying

(Continued from page 294)

A 6-in diameter tube with a hay-cutting edge is in use to remove core samples.

An 8x8-ft bin was reported large enough to approximate closely loading conditions in larger mows.

Portable heating units suitable for hay drying and other farm uses were suggested as worthy of further investigation and development.

Farm Hay-Drying Equipment and Practices. Some large operators were reported using wagon or batch-drying units to dry hay to safe moisture content in two to three hours.

There was one report of a threshing machine blower being used successfully to elevate hay into a mow. Its capacity was indicated as up to 5,000 lb per hour.

A silo-type drier with elevator was indicated as low in labor requirement and being used successfully as a batch drier. Other types of auxiliary drier buildings for drying hay and other products were suggested for use in the same manner.

It was indicated that improved choppers and balers, large and strong enough to handle these jobs economically, are counteracting early setbacks to these methods of handling which result from machines of inadequate capacity.

Spun glass filters for exhaust gases introduced into air-circulating systems were indicated as giving satisfactory results.

Field forage harvesters were favorably mentioned in connection with the cost and labor factors in putting up chopped hay.

A suggested opportunity for equipment improvement called for reduced blowing and dust in handling dry chopped hay.

Favorable mention was given to a field pickup baler which turns out small bales or briquettes of hay not sliced or tied, but held intact by the manner in which the hay is tucked in, in forming the bales. The bales, 6 to 8 in thick, are reported to handle easily and respond well to mow drying.

For areas in which field curing is normally practicable, adaptation of one-half to one-third of mow capacity for supplemental drying was suggested as a reasonable hedge against unfavorable weather.

Conclusion. The conference was not able to draw as clear a picture, as it had been hoped it might, of current good practice in barn hay curing, and of further research and development offering best apparent prospects of fruitful results. This summary of its deliberations is presented for what it may be worth as a step toward condensation and clarification of existing knowledge and viewpoints on the subject.

Soil Erosion Studies—Part IV

Soil Erosion, Soil Loss, and Some Effects of Soil Erosion

By W. D. Ellison

MEMBER A.S.A.E.

SOIL erosion has been defined as a process of detachment and transportation of soil materials by erosive agents. All of us have probably observed the erosion process at various times, as wind or water separated and displaced particles from the soil mass and set them in motion. Many of us have tried to measure this erosion and express it quantitatively. The usual practice has been to measure some product of the erosion process, and then assume that this product varies in proportion to the erosion process which produces it.

One of the early measurements made in soil erosion investigations was that of soil lost from an area on which the erosion process was active. For making such measurements a point was selected in the drainageway of a watershed, or at the lower edge of a runoff plot and the amount of soil transported by the runoff from the upstream area was measured as it passed this point. The quantity of soil loss was then assumed to be proportional to total soil erosion on the area. If the area was very small, and of uniform soil, cover, slope, and smoothness of surface, and if the surface contained no obstructions which caused soil deposits, this assumption of proportional relationships could be approximately correct.

The true quantity of soil erosion, however, is obviously the sum of the detachment and transportation in the soil erosion process. Each time the process is active, energy is expended in detaching and transporting soils, and the result is a quantity of soil erosion. However, there need not be soil lost from a field each time that erosion occurs. If it were possible to have soils detached and transported some distance across the surface of a field, and then all of the particles returned unimpaired to their initial positions, there would then be no soil loss, but there would be erosion which could be expressed quantitatively in terms of tons of soil detachment on each acre, and ton-miles of transportation per acre. Under these conditions erosion hazards would exist, and we could evaluate these hazards in terms of detachment and transportation.

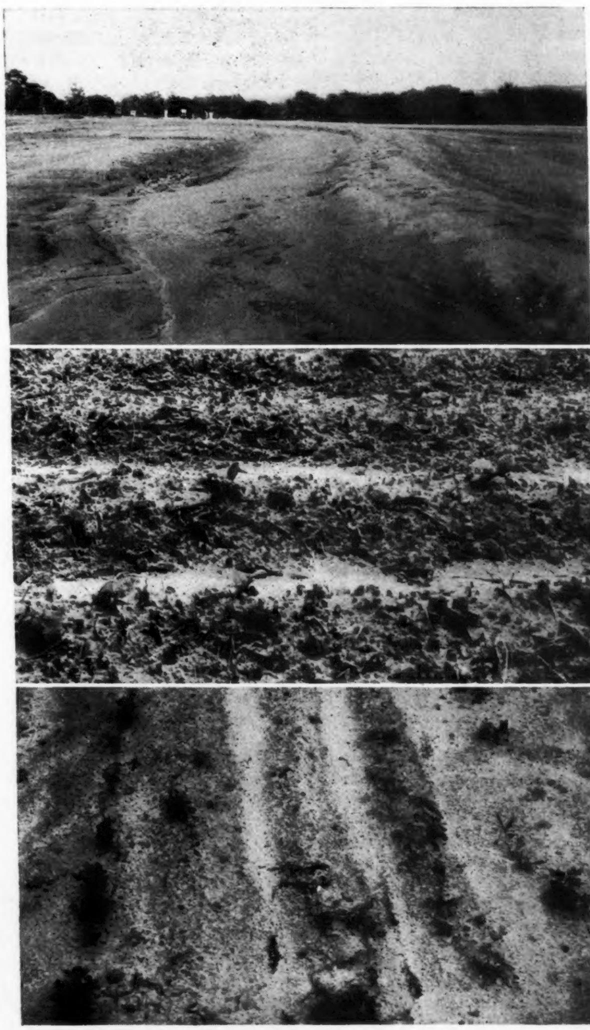

Fig. 1 *(Top)* Eroded soil almost fills this terrace channel • Fig. 2 *(Center)* Splash erosion has removed from one to two inches of soil from the tops of these contour ridges. When the splashing soil fell into the surface water between ridges, the organic matter and clay floated along the contour and off the field. To stop this erosion one must check falling raindrops before they strike the soil • Fig. 3 *(Bottom)* Compare this view with Fig. 2. Here is heavy sand in each tillage mark; splash erosion continues active each time it rains

This paper was prepared expressly for AGRICULTURAL ENGINEERING and is the fourth of a series. Parts I, II, and III appeared in consecutive issues beginning in April, 1947.

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It is important that we distinguish between soil loss and soil erosion. I had this point demonstrated in a most forceful manner in the Blacklands of Texas about 14 years ago. While traveling along a highway one day, I observed a stone fence about 12 ft high that was serving as a dam across a small valley. Back of this dam, soil was deposited to within about one foot of the crest, and the surface area of this deposit was approximately three acres. The total drainage area above this outlet comprised about 60 acres of cultivated, rolling fields, and white marl was now showing through the topsoil at a number of points on the steeper slopes. When the farmer was questioned about this project, he pointed with pride to the dam as he said, "Other farmers could control their erosion, too, if they would just work as hard as I have." But as he lifted his eyes to the white hillsides, his expression betrayed his boast of having controlled erosion, and he displayed a rather pained and perplexed look as if he were questioning the wisdom of his own work. It was apparent that he had stopped soil loss *from* that field, but he most certainly had not stopped soil erosion *on* that field.

Soil erosion occurs on the surface of a field whenever the forces bearing on a point in the surface soils are not in balance; whenever the conditions are not satisfied for making $\Sigma x = 0$, and $\Sigma y = 0$. When these conditions for stability are not satisfied, certain erosion hazards are present, and the magnitude of these hazards will be proportional to the magnitude of the external forces that are in excess of the soil's resistance.

The Texas farmer referred to above had almost eliminated soil loss from his field by building a dam in the drainage outlet. To eliminate soil erosion he would have had to develop soil stability over the entire surface of the field. We must exercise great care when we assume that soil loss, a product of erosion, is proportional to the erosion

process. The assumption that by eliminating soil loss *from* a field, we also eliminate soil erosion *on* the field must also be questioned and carefully tested before we accept it for any given situation.

A system of terraces on highly erodible soils will serve as a series of dams to check soil loss, and because they check surface flow, they also reduce the erosion caused by surface flow. Fig. 1 shows a terrace that has been very effective in preventing soil loss *from* the field, but it has not effectively controlled soil erosion *on* the field.

The same is true of the contour ridges on each crop row, Fig. 2. They, too, have been effective in checking the erosion caused by surface flow, as well as in checking soil loss from the field. In this figure there are 4 to 6 in of coarse, sterile sand deposit between the rows. The light organic matter and clay fractions were floated away. To prevent this floating away (assuming some runoff cannot be prevented), one would have to prevent the erosion which detached the soil and set it in motion.

Fig. 3 shows contour tillage marks approximately one foot apart. Here again soil loss has been checked, but the coarse sand deposits should serve to warn us that erosion remains active.

Figs. 1, 2, and 3 should remind us that there are two principal erosive agents associated with rainstorms, and that when we arrest only one of these and leave the other unchecked, erosion continues active. Terraces, contour ridges, and tillage marks on the contour will check the agent of surface flow, which scours rills and gullies, and which serves so effectively in transporting soils, but they do not impede the falling raindrops which detach sheets of topsoils and set these in motion through the splash erosion process. To check this agent (the splashing raindrops) we need soil covers of growing crops or mulches.

SOME EFFECTS OF SOIL EROSION

Part III of this series of articles took up some effects of soil erosion on infiltration and runoff. There are many other effects of erosion, which have an important bearing on problems of the land. Many of these have been studied and discussed by others. Some that are believed to be important and on which we need more information include the following: The effects of soil erosion on (1) spray irrigation, (2) drainage, (3) silt problems, (4) loss of seed, fertilizers and feed, and (5) changes in the soil that affect tillage operations, aeration and water-holding capacities of the soils.

Erosion Affects Spray Irrigation. Impact and splash of falling draindrops will destroy clods and aggregates of soil and puddle the surface materials to form a slowly permeable soil layer on the outer surface which tends to seal and almost waterproof the land[1,2,3]. When we add to the natural raindrops the impacts of waterdrops from spray irrigation systems, we further aggravate this surface sealing problem.

Spray irrigation is usually applied at low rates which cause very little or no runoff at all. This causes practically all of the colloidal materials and other clay fractions released in the splash process to be left on the surface or carried into soil pores. It has been reported that, in some areas where spray irrigation methods have been used over a period of years, there is some trouble in getting water to infiltrate. It would be interesting to inspect some of these profile materials and contrast them with similar profiles on which spray irrigation has not been used.

Fig. 4 shows "splash cards" that were used in two separate spray tests. These are white cardboards, 5x7 in, and they were each clipped onto a small stake about the size of a lead pencil to hold them upright and in place for the experiments. They were set with a 7-in edge parallel to the soil surface and suspended about ½ in above the soil. This made a splash plate 7 in long and 5 in high.

[1]Duley, F. L. and Kelly, L. L. Effect of soil type, slope, and surface conditions on intake of water. Nebr. Agri. Exp. Sta. Res. Bul. 112, 16 pp., 1939.

[2]Lowdermilk, W. C. Influences of forest litter on runoff, percolation and erosion. Jour. Forestry, 28: 474-491, 1930.

[3]Ellison, W. D. Soil erosion studies — Part III. AGRICULTURAL ENGINEERING, June, 1947.

The same set of nozzles was used for both experiments, but the pressure was different for each. This set consisted of one ¼-in nozzle and one 3/16-in nozzle. The spray which caused the soil splash on the top card in Fig. 4 was applied with a pressure of 47 psi, while the spray which caused the splash on the lower card was applied with a pressure of only 20 psi. From a study of these cards, it is apparent that the 20-lb pressure produced much larger drops, and caused more splash erosion and soil puddling than did the 47-lb pressure. These results suggest a need for investigating the splash erosion produced by different nozzle and pressure arrangements. We could probably make a *splash rating* of different sprinkler systems operating under different pressures. Such a rating would enable the irrigator to select systems of nozzles and pressures that would produce minimum surface sealing. Splash ratings could be made with *standard soil* in a number of sand cups[3]. On many soils a low splash rating will be necessary to avoid the formation of surface seals. It is also probable that on some soils a low splash rating is necessary for preserving permeability of the profile materials. This aspect of the problem that pertains to the effects of surface puddling on profile materials remains highly speculative.

Some Effects of Erosion on Drainage. When soil erosion increases the runoff[3], it becomes necessary to construct and maintain larger drainage channels. Erosion on the watershed also tends to accelerate silt deposits that restrict channel areas, and often the deposits in these restricted areas will support vegetal growths that further impair channel capacities[4]. Because of these and other reasons, the drainage engineers have for years advocated soil erosion control on the drainage area as a means of reducing costs of constructing and maintaining open-drainage channels.

[4]SCS-TP-62, March, 1947, by C. E. Ramser; also 1926 U.S.D.A. Yearbook, same author.

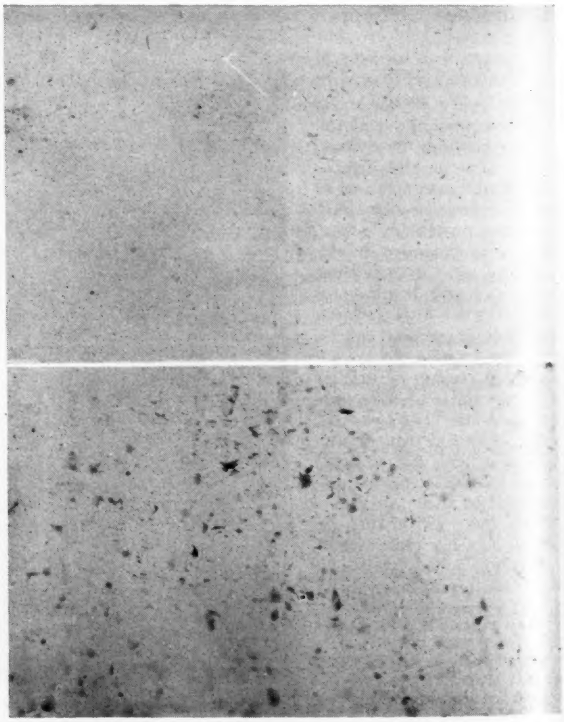


Fig. 4 The two white cards shown here, each 5x7 in, were used as splash boards for two experiments in spray irrigation. The upper card shows very little soil splash, while the lower one shows that some large drops were present to splash and paddle the soil. The same set of nozzles was used for each test, but 47-lb pressure was used in the upper card test, and 20-lb pressure for the lower. (Photo courtesy of Seabrook Farms)

Fig. 5 *(Left)* This surface deposit compares with that shown and described in Fig. 6 at the right. It may almost waterproof the land • Fig. 6 *(Right)* This deposit in O'Shaughnessy Reservoir near Columbus, Ohio, is comprised mostly of organic matter and clay — the type of material that binds aggregates together and the type that is released from the aggregates by splashing raindrops

A study of the effects of splash erosion on infiltration[3] reveals one more reason for controlling soil erosion for purposes of improving drainage, especially tile drainage. Splash erosion that retards rates of infiltration will impair effective operation of tile drains. Often the clay fractions and other fine and light materials released by the splash process on upland areas are floated down onto the bottomlands to form an impervious seal which will cause water to stand on the surface for days, while flow in the tile drains is at only a small percentage of their capacities. In Fig. 5 the surface has been covered with a slowly permeable material which was undoubedly washed down from higher lying fields. In view of these effects of the splash erosion process, the drainage engineer in the future may do well to survey proposed drainage areas with a view to evaluating the effects of splash erosion on the land before designing the drainage system.

Erosion and Silt Problems. When eroded soils are deposited by moving water there is a tendency to separate the eroded materials by particle sizes. The first materials to be deposited will contain the materials of lowest transportability, whereas the materials of highest transportability will be deposited last — the farthest downstream. The amounts of fine and highly transportable materials that are removed from a watershed tend to be proportional to the splash erosion process.

When soil materials are eroded by the splash process, there is much more breaking up of the aggregates than when the soil is eroded by the scouring action of flowing water. Consequently, there is a greater release of clay fractions and organic matter which are highly transportable when the soil particles are detached and set in motion by the splash of falling raindrops. These fine and light materials are often floated miles downstream to be deposited in large reservoirs, while the less transportable parts of the eroded soil are usually deposited upstream. These facts indicate that when farm ponds and small upstream reservoirs are located on or near the base of a sloping field, we may be most interested in checking the rill and gully erosion that supplies a great part of the heavy materials deposited in them. But in protecting large downstream reservoirs, control of the splash erosion process, which releases most of the highly transportable materials, can be of greater importance.

Fig. 7 This view shows the kind of poor pasture where seed and fertilizers spread on the surface may be mostly lost in a beating rainstorm. Refer also to Fig. 7 in the author's paper, "Soil Erosion Studies — Part II", (AGRICULTURAL ENGINEERING for May, 1947, page 200), as well as to Fig. 2 and 3 of this paper. From these one may gain some idea of how fertilizers and seed may be splashed out of surface soils, even on fairly level lands

Fig. 6 shows a silt deposit in the O'Shaughnessy Reservoir near Columbus, Ohio. This fine and light material is apparently high in colloidal matter, and it is characteristic of the materials released from the soil aggregates that are broken down by raindrops. It is also very similar to the deposit shown in the dry pond, in the foreground of Fig. 7 of "Soil Erosion Studies—Part II (see AGRICULTURAL ENGINEERING for May, 1947, page 200).

It has been reported by experts on the subject that the colloidal matter, small clay and humus fractions in runoff water are particularly bad for fish. This report raises the question whether a ton of this fine material carried from a field where splash erosion is active does not destroy more fish life than many tons of sand and whole soil aggregates eroded by the scour process.

We may obtain a general idea of the effects of splash erosion on streams and reservoirs, by contrasting mountain streams in wooded and grassed areas with streams of much lesser gradients, in level, cropped areas. The flow in mountain streams usually reaches valley bottoms over much greater energy gradients than does flow from cropped fields, but in the wooded mountains the surfaces usually contain enough cover to check splash erosion effectively.

In conclusion, we may expect terraces, contour ridges, and other impediments to surface flow to serve as very effective protection against excessively large upstream deposits of coarse silt. Soil covers comprised of growing vegetation and mulches are needed to check effectively the splash erosion process, a process that releases a large part of the colloidal matter and fines so harmful to fish life and which usually constitute a large part of the fill found in large, downstream reservoirs.

Erosion Removes Seed, Fertilizers, and Feed. When seed and fertilizers are spread on the surface, soil erosion processes can remove a large part of these materials, even without measurable erosion or soil loss taking place. This is especially true on steep slopes, and on other fields where the soil surface is not protected by a mulch or growing cover. Even on fairly level areas these losses can be high during beating rainstorms, particularly so if the seed are so light that after once being splashed into the air they will be carried away as they fall back into the flowing surface water.

Fig. 7 shows a poor pasture on a steep slope. A heavy rainstorm could remove practically all of the seed and fertilizer that might be spread on the surface of this hillside. Experiments have shown wide variations in results from spreading seed and fertilizers on the surfaces of run-down pastures to improve the grass. I have observed that when the rainfall which follows surface treatments is gentle, so that it does not splash the seed and fertilizer and cause them to be carried away, very good results may be obtained from surface applications. But when beating rains follow these applications, there may be much waste of seed and fertilizer materials on poorly protected slopes. These observations cause us to ques-

tion the desirability of spreading seed and fertilizers promiscuously on sloping land that has little or no surface protection from plants or plant residues.

Some observations I have made at Coshocton, Ohio, demonstrated that a heavy rainstorm composed of large drops can splash bluegrass and clover seed out of the ground even after sprouts have reached almost an inch in length, and after the green plant is beginning to show above the surface. This occurred on Muskingum silt loam during the month of April and on a surface slope of about 30 per cent.

Many of the light seed and grains which serve as feed for wildlife are carried from the field by soil erosion. When raindrops splash on the surface of a soil they set much of the small seed and light grains in motion. Even though the surface flow acting alone would not remove these from the land, the effects of raindrops in splashing this material into the air and keeping the surface water highly agitated will cause these materials to be transported. A good cover on the land either in the form of a mulch or growing crops is necessary to break the impact of the raindrops and to check this loss. In addition to removing these materials from the fields, splash erosion has a leveling effect on the soil surface. It splashes down the tops of high points and fills in the depressions. This process will bury grain and other feed that is on the surface. One can well imagine what the effects of splash erosion on burying the heavy grain and other feeds would have been on the field shown in Fig. 2. It seems doubtful that this aspect of the erosion problem has been given due consideration by those interested in the feeding and protection of wildlife. Indications are that we cannot usually expect feed to remain available on the surface of the land where soil is not protected against the splash of raindrops.

Erosion Causes Soil Structure Changes. When splashing raindrops break down clods and aggregates and release humus and clay materials, the soils will tend to puddle and compact. This puddling is a surface phenomenon, but in the process the water is made so turbid that colloids and some fines approaching colloidal dimensions are carried down into the profile. Removal of these from water percolating downward through the profile, will tend to consolidate profile materials, give it strength and firmness, and decrease its permeability. On the surface of the soil an even more compact and less permeable structure is developed under puddling.

Both of the above-described structural changes in the soil will affect various aspects of our field problems. One effect of soil compactions, of special interest to engineers, is the firmness developed, which may make tillage more difficult and increase the power requirements for tillage operations. This occurs in many clayey soils which have aggregates that are easily broken down by splashing raindrops — broken down into a single grain structure. Soil aeration, too, is checked when the soil surface is puddled and the profile materials are made more dense by the intake of turbid water.

Most standy soils will splash more readily than do the clay soils, but they do not tend to compact and consolidate as readily as the clays. When sands are splashed into the air, and the broken aggregates fall back into temporary suspension in highly agitated surface water, they tend to lose a large part of their humus and clay materials which are seldom if ever bound into strong aggregates. Over a period of years the sandy soils that are not protected against splash erosion will tend to lose both their clay fractions and their organic matter. Many of these soils we find becoming more and more like beach sands as the years go by. Unlike the clays which become more compact under splash erosion, these soils become less firm and tend to lose their water-holding capacity. There have been reports of sandy soils in humid regions losing so much of their water-holding capacity that they enter a period of drought within a few days after a midsummer rain. Some of these will lose so much of their water-holding capacity that they cannot be farmed successfully without frequent applications of irrigation water. It seems probable that we shall have to provide much more soil cover on these fields before marked improvements in soil can be achieved.

Custom Work

(Continued from page 281)

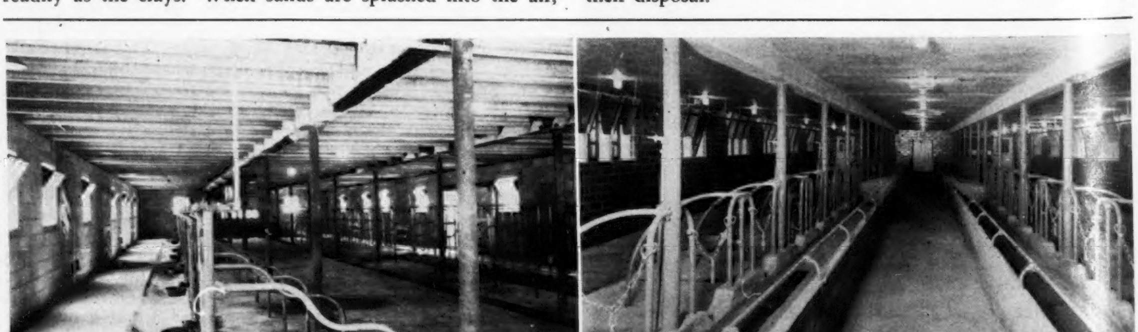
Quality of work without sacrifice of output will require careful selection of equipment plus skilled operators. Farmers will be particularly critical of quality in strictly farm operations in which they are competent judges of quality.

Timeliness will impose on the contractor the necessity of limiting his contracts according to his daily capacity, with reasonable allowance for unfavorable weather, in the case of operations in which time is critical. It will further require systematic maintenance to insure dependability of equipment.

Full use of primary power and other non-seasonal equipment and operator time will require a continued backlog of work orders for jobs not critical as to timing or weather, to be sandwiched in between jobs on which timing may be critical. It will require further a variety of operating equipment and ability to undertake several types of jobs, to provide sufficient work within an economic radius of operation.

Custom work for farmers is not going to be anybody's gold mine. Its justification and opportunity for service is in close, carefully calculated margins and cost-cutting methods. It appears that there will be continuing opportunity in many communities for one or more full-time or part-time farm power equipment contractors. It will be an opportunity to add economically to the flexibility and capacity of the farm equipment setup in the community.

Farmers are using money economy more extensively and effectively than ever before. They are distinguishing more carefully and intelligently between the jobs they can best do for themselves, within the limits of their available time, and those which they can better afford to hire done for them. They will not quickly return to their old ways as long as they can use a money economy to help them make the most of the land, buildings, equipment, livestock, crops, markets, labor, special skills, management abilities, and other facilities at their disposal.



Concrete mow floors are being used more and more in construction of new barns. They are strong and firesafe, providing the owner maximum protection against losing his herd from fire. *Left:* This mow floor is made of concrete joists which support a concrete slab floor. Both the joists and slabs are reinforced. • *Right:* A reinforced, cast-in-place concrete flat slab mow floor provides a smooth underside. It is easy to keep clean and can be painted with a lasting coat of white portland cement paint.
(Photos courtesy of Portland Cement Association)

Drying Baled Hay with Forced Air

By John W. Weaver, Jr., C. D. Grinnells, and R. L. Lovvorn
MEMBER A.S.A.E.

THE value and adaptability of the barn hay drier has been well established in several sections of the Southeast. A recent survey[1]* shows the number of installations by states as follows: Virginia, 333; Tennessee, 122; North Carolina, 85; Mississippi, 11; Georgia, 10; Alabama, 8; and South Carolina, 3. The major portion of these installations have been used for drying long, loose hay. Five states reported limited experience in drying chopped hay. Tennessee reported satisfactory results with three installations for drying baled hay, though all bales were purposely broken when placed on the driers.

No reports of research on the drying of baled hay have been issued in the Southeast. Wileman reported in 1944[6] on tests of drying baled hay on a slatted floor with an air flow of 9 to 9½ cfm per sq ft of floor. Indications were that the moisture content of hay, when baled, should be 35 per cent or less and around 20 cfm per sq ft of floor should be used. He concluded further that hay should be placed on the drier within two hours after baling to prevent heating.

Miller[4] concluded that there may be a greater loss of air between bales for a given mass of baled hay as compared to drying a similar mass of long, loose hay and at least four times as much air should be provided to dry the baled hay which may come in at 50 per cent moisture, as has been used in drying long hay containing 35 per cent moisture. Miller also found some mold in the top tier with bales placed nine tiers deep on a slatted floor, using supplemental heat only part of the time during the drying period. He reported indications that, when more than five tiers of bales were used, the added tiers received a smaller per cent of air and thus dried slowly, and that it is easier to provide more air than extra heat.

Frudden[2], reporting on Jennings' tests with long, loose hay at Cornell, concluded that all damp hay placed in the mow must be reduced in moisture at a rate to reach 10 per cent within seven days in order to insure hay free from mold.

Objectives of Study. Because of the widespread interest in the possibilities for drying baled hay with forced air in North Carolina it was decided to conduct a preliminary study to determine the need for initiating a full-fledged research project on the subject. A review of the work reported by other investigators, as indicated above, together with other observations led to the adoption of the following objectives for this study:

1 Determine uniformity of bales where baling is done with a conventional baler under field conditions.

2 Determine, to some extent, the rate of air flow through and resistance pressure encountered in drying baled hay with forced atmospheric air.

3 Determine effectiveness of drying by forcing air through bales as compared with forcing air around bales.

4 Determine rate at which heat can be removed from baled hay by forcing air through bales as compared with forcing air around bales.

Management of Hay Prior to Tests. The hay was made from third-cutting alfalfa at a maturity of about two-thirds bloom. The growth was good with a maximum of 28 in from tip of plants to soil surface. Cutting was started with two tractor-mounted mowers at 10:45 a. m. on July 15, 1946. At this time the moisture content of the growing plants was 72.0 per cent, and that of the top 2 in of soil in the field was 9.1 per cent. All moisture contents, as given in this paper, have been calculated on a wet-weight basis. The hay was left in swath during the first day after cutting. The atmospheric conditions and rate at which the hay dried in the field, during this first day, are shown graphically in Fig. 1.

During the first night after cutting, the hay was subjected to about 2.5 in rainfall over a 3-hr period. At 9:45 a. m. of the second day the moisture content of the hay was 72.1 per cent. The weather was overcast throughout the second day and the hay was left in swath. Fair weather prevailed on the morning of the third day and raking was started, with a side-delivery rake, at 10:00 a. m. At this time a sample taken from the swath showed the hay moisture content to be 40.8 per cent and that of the top 2 in of soil to be 16.4 per cent.

Baling was started at 11:15 a. m. of the third day, at which time samples taken from the windrow showed the hay moisture content to range from 47.4 to 63.7 per cent. A conventional baler was pulled through the field by a tractor and hay was baled by hand-forking from the windrow into the baler. All bales were tied with wire and were 17 by 22 in in cross section. The length of the bales was varied to meet the needs of the tests.

Only one light-weight bale was used in this experiment and that was used to determine air flow through an individual bale. All other bales were termed "heavy" bales, and were made with the same adjustments on the baler. The light-weight bale was made by removing all compression from the springs on the baling chamber. The heavy-weight bales were made by putting compression on the baling chamber springs to a point where it was thought the bales thus made could unquestionably be handled without coming apart. After each adjustment four bales were allowed to come through the baler to clear it of any effect from the previous adjustment. Bales thus passed were discarded from those used in the experiment.

Uniformity of Bales. According to Smith[5] the density of the bales is regulated by closing the outlet of the baler to such an extent that it will be harder for the compressed hay to be forced out. He states, further, the greater the force required to move the hay out of the baling chamber, the greater the density will be. Miller[4] concluded that good drying starts with uniform baling and fairly uniform moisture in the bales in one tier.

Density was selected as the factor to be observed in determining uni-

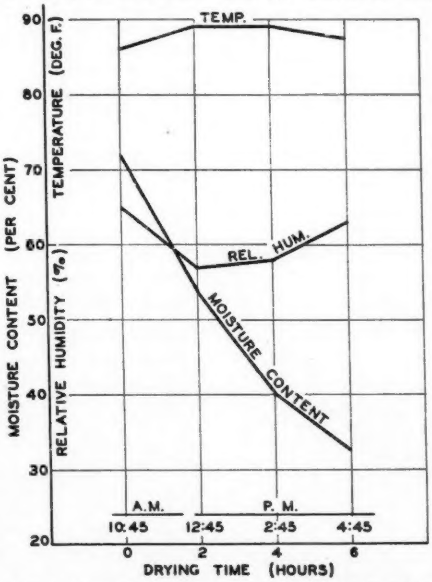


Fig. 1 Atmospheric temperature and relative humidity with rate of drying of alfalfa hay in swath as related to drying time and time of day on July 15, 1946, at Raleigh, N. C.

This paper was presented at the Third Barn Hay-Curing Conference sponsored by the American Society of Agricultural Engineers, at Chicago, Illinois, December, 1947. Revised and published with the approval of the Director, North Carolina Agricultural Experiment Station, as Journal Series Paper No. 257.

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*Superscript numbers refer to appended references.

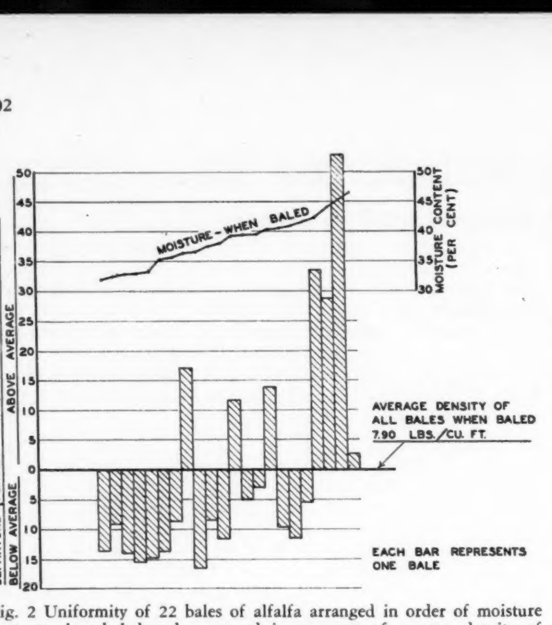

Fig. 2 Uniformity of 22 bales of alfalfa arranged in order of moisture content when baled and expressed in per cent of average density of all bales when baled

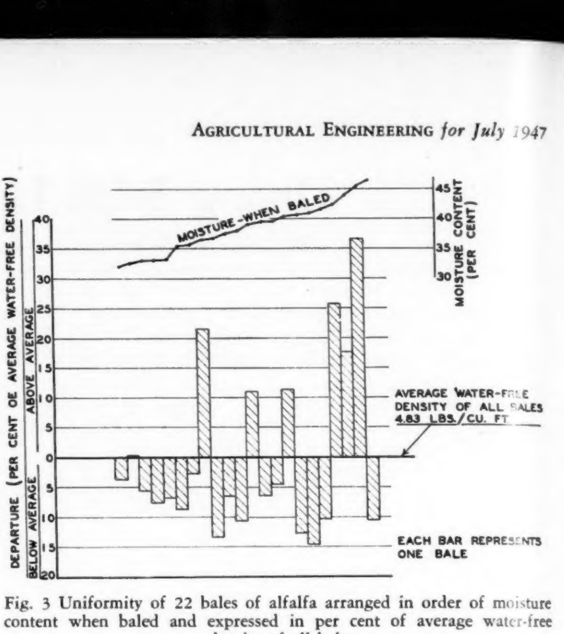

Fig. 3 Uniformity of 22 bales of alfalfa arranged in order of moisture content when baled and expressed in per cent of average water-free density of all bales

formity of bales, since it conceivably has more bearing upon the rate and uniformity of drying with forced air than any other factor that might be selected. All densities reported herein are expressed in pounds of dry matter plus pounds of water present in the bale per cubic foot of bale volume at time of observation. Of course, the term "water-free density" includes only dry matter.

Twenty-two bales of alfalfa were observed for uniformity. Each bale was weighed after baling and again after seven days of drying by forced atmospheric air. Samples for moisture determination were taken from each bale at the end of the seven-day drying period. From these sample moisture determinations and the total weight of each bale, before and after drying, the moisture content was calculated for each bale after baling, and at the end of the seven-day drying period. From the observed data the water-free density of each bale was also calculated. It is recognized that this method neglects the respiration loss of dry matter, during the drying period, in determining the moisture content of each bale prior to drying. However, under the conditions of these observations, this neglected factor would be of small magnitude since the respiration loss could hardly amount to more than one or two per cent of the total dry matter. MacDonald[3], surveying the work of several investigators, reported respiration losses of dry matter and nutrients occurring in hay stored under normal conditions. These losses, for alfalfa hay, were from 3.5 to 4.1 per cent after three months storage at 25 to 27 per cent moisture content. Densities reported herein are not affected by this neglected factor since the weight of both dry matter and water, present at the time of observation, was recorded and used in determining density.

The uniformity of the 22 bales observed after baling and prior to drying is shown by the bar chart in Fig. 2. For comparative purposes the data for the bales have been arranged in order according to their respective moisture contents when baled. The comparable density of each bale, when baled, is depicted by its departure from the average density of all bales, when baled; the departure is expressed as a percentage of this average. Likewise, the uniformity of the 22 bales on a water-free basis is shown in Fig. 3.

It may be observed from Figs. 2 and 3 that there is a trend for the density of bales to increase, to some extent with an increase in moisture content of the hay when baled. There is a similar trend with an increase in the length of bales as shown in Figs. 4 and 5.

By comparing Fig. 2 with Fig. 3 it can be seen that all bales, as a whole, are more uniform in density when all water has been driven off. Fig. 6 has been prepared to show that not only does the average density of all bales decrease as drying progresses, but also that the bales as a whole become increasingly more uniform in density as drying progresses and the hay approaches the water-free state. From the observed data it was found that the maximum departure from average density when baled was decreased 50.4 per cent by the seven-day drying period and at the same time the minimum departure from average density was decreased 87.0 per cent. It was calculated that the maximum departure from average density when baled

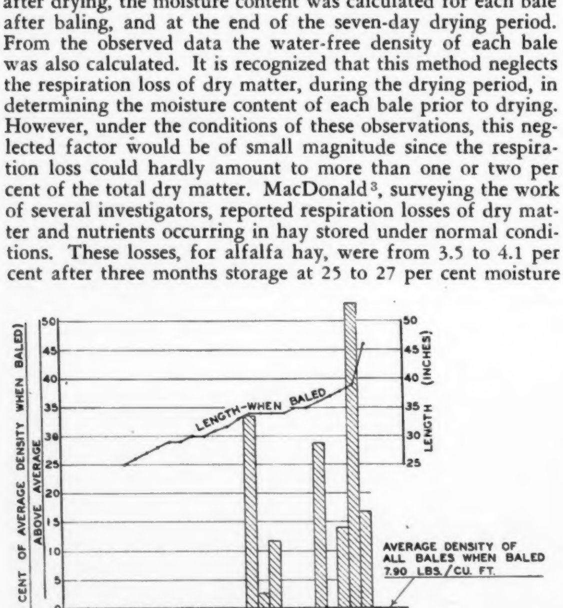

Fig. 4 Uniformity of 22 bales of alfalfa arranged in order of length when baled and expressed in per cent of average density of all bales when baled

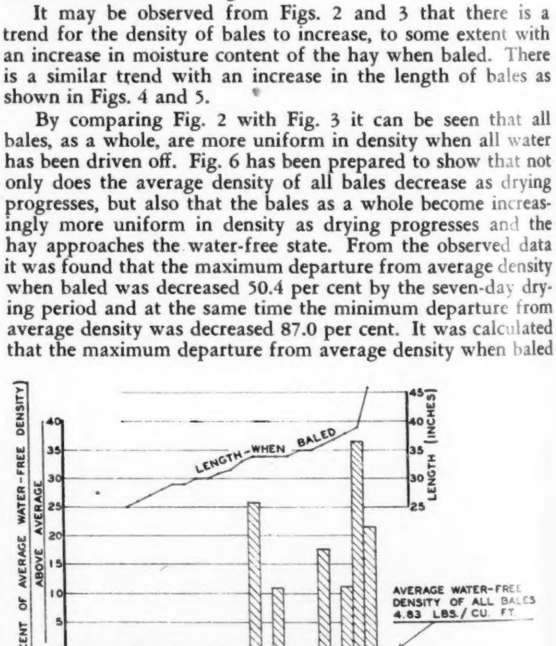

Fig. 5 Uniformity of 22 bales of alfalfa arranged in order of length when baled and expressed in per cent of average water-free density of all bales

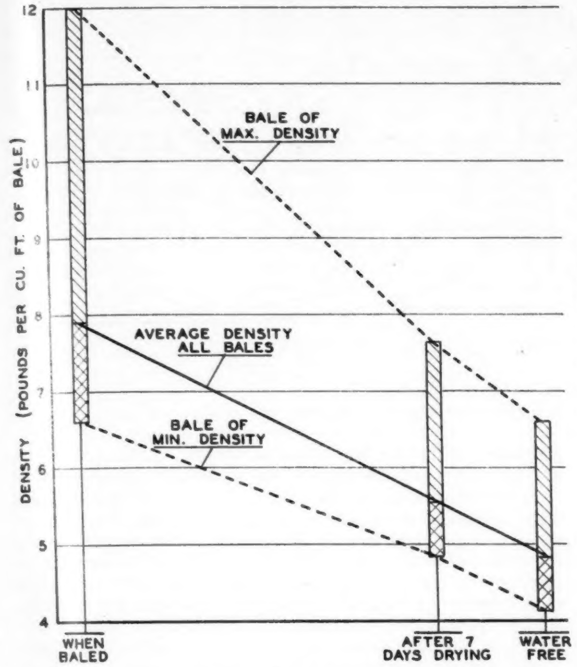

Fig. 6 Chart showing that not only does baled alfalfa decrease in density as drying progresses, but also the bales become increasingly more uniform in density

was decreased 57.8 per cent by drying to a water-free basis, and on the same basis the minimum departure from average density was decreased 95.7 per cent.

The average moisture content of all bales, when baled, was 39.16 per cent; after seven days drying it was down to 13.07 per cent. Under the conditions of these observations it was found that the difference between maximum and minimum density of all bales, when baled, was reduced 48.8 per cent by seven days drying; on a water-free basis this same difference was reduced 55.0 per cent.

Air Flow Through Bales. Wileman[6] and Miller[4] reported measurements of air flow in drying bales of hay stacked in tiers on a slatted floor above a plenum chamber or in conjunction with an air tunnel. No information has been published on the actual flow of air through individual bales and the resistance pressure thus encountered. It was decided that such fundamental information would prove valuable in assisting with the design of a system or systems for drying baled hay.

To determine these factors a tight floor of 1/4-in plywood was installed above the slatted floor of a corn drying bin. An opening 2 in wide and 28 in long was cut centrally in this tight floor. Bales were prepared of such dimensions that when placed on the floor the opening in the floor would be overlapped by 10 in all around, or 22 by 48 in. A sheet metal box was constructed 31 by 52 in in plan and 28 high to cover the bale and act as a collector of air emerging from the bale during test. A 5-in tube, 60 in long, was inserted in one end of this box to provide an outlet for all the air flowing through the bale. The velocity of air flowing through this tube was measured by a velometer in conjunction with a duct jet and from these measurements the volume of air flow was calculated.

Only two bales were prepared for this test, one "heavy" and one "light" in weight. Prior to placing either bale on the tight floor a 3/4-in layer of asphalt roofing cement was spread evenly around the opening in the floor and outward from the opening a distance of 18 in. A 1-in area immediately around the opening was left clear of the cement to prevent interference with the flow of air through the opening. Each bale, when tested, was placed centrally over the opening, pressed down into the roofing cement and held in place by external clamps to prevent leakage of air between the floor and the bale. Likewise, the metal box was placed centrally over the bale, pressed down into the cement and held in place by weights.

A static tube was inserted in the metal box and another was inserted in the tight floor to observe static pressures within the box and beneath the floor. Thus the effective static pressure related to air flow through the bale was measured by connecting one static tube to one leg and the other static tube to the other leg of an inclined U tube partially filled with gasoline of predetermined specific gravity. From these measurements and the observed angle of the U tube with the horizontal, the effective static pressures were calculated in inches water column.

The results from these tests to determine the flow of air through individual bales and the resistance pressures encountered are shown graphically in Fig. 7. The density and moisture content of each bale, at time of observation, are recorded in Table 1.

TABLE 1. DENSITY AND MOISTURE CONTENT OF BALES AS OBSERVED FOR RESISTANCE TO AIR FLOW

	Density, lb per cu ft		Moisture content per cent (wet basis)	
Bale No.	Before drying	After drying	Before drying	After drying
1	6.64	4.57	38.6	10.8
3	9.24	6.73	36.4	12.7

As previously stated, density was employed as a measure of uniformity of bales and by this measure it was found that bales become increasingly more uniform as drying progresses. From this it might be thought that the resistance to the flow of air through a number of bales would become more uniform as drying progresses. By comparing the data shown in Fig. 7 and Table 1, it was found that though bale 1, before drying, and bale 3, after drying, were of about the same density at time of observation, there was 57 per cent more air flowing through bale 1 at 0.5 in static pressure in each case.

The resistance of baled alfalfa to air flow appears to be related to the water-free density of the bale as modified by some factor. This factor may result from actual shrinkage in volume of the leaves and stems and/or respiration loss of dry matter during drying. Considerable additional experimentation

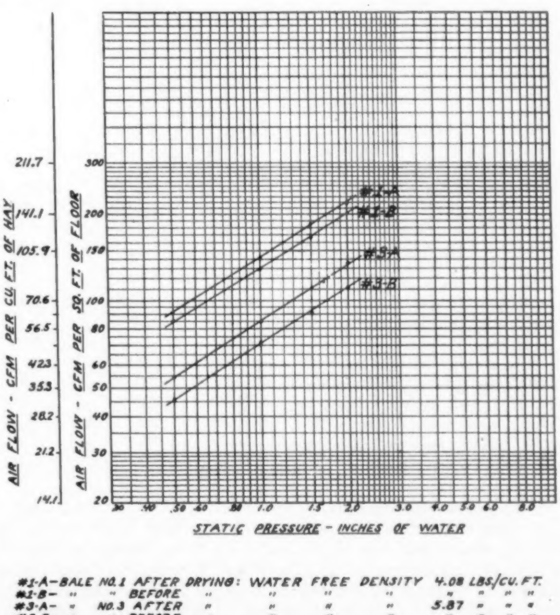

Fig. 7 Resistance of single bales of alfalfa hay of different density to air flow, before and after drying

will be necessary to determine whether or not this relationship exists. At any rate it is almost certain that the over-all individual resistances to air flow of any given number of bales will not necessarily become more uniform as drying progresses.

Drying by Forcing Air Through and Around Bales. Two identical corn drying bins with false slatted floors were used to determine the effectiveness of drying by forcing air through bales as compared to forcing air around bales. All bales used for these observations were 17 by 22 in in cross section and were varied in length to fit a prearranged plan for storage in the drying bins. Bales were stored three tiers deep in both bins.

In bin 3 all bales were stored with their 22-in sides horizontal and were pressed tightly together, side to side and end to end, in an effort to eliminate all free passageways for air to flow between or around bales.

In bin 4 all bales were stored with their 17-in sides horizontal to allow a 2-in free passageway for air to flow between and around bales. A free passageway between tiers was provided by the placement of 2x2-in strips. Thus, air forced through the bin had free access to all sides and ends of all bales.

Two identical direct-driven blowers, with backwardly curved blades, one on each bin, were operated continuously for seven days blowing atmospheric air upward through the bins. Neither blower was adjusted to provide a predetermined static pressure or air flow. Both blowers were allowed to deliver their maximum air flow against whatever static pressures should develop. Rainfall occurred one day during the drying period of seven days while the atmospheric relative humidity ranged between 52 and 100 per cent and the temperature ranged between 61 and 89 F.

Table 2 sets forth comparative observations of these two methods of drying. With the air flow obtained and under the conditions of these tests it appears that drying by forcing air around bales is as effective as drying by forcing air through bales of alfalfa. The static pressure encountered in drying by forcing air around bales was only one-third of that in drying by forcing air through bales.

TABLE 2. DRYING BALED HAY WITH A CONTINUOUS FLOW OF ATMOSPHERIC AIR FOR SEVEN DAYS. A COMPARISON OF FORCING AIR THROUGH BALES TO FORCING AIR AROUND BALES

	Air through bales Bin No. 3	Air around bales Bin No. 4
Total volume of hay, cu ft	73.01	70.49
Total air flow through bin, cfm	1830	2160
Air flow per cubic foot of hay, cfm	25.1	30.6
Air flow per square foot of floor, cfm	100.0	123.4
Average density of bales before drying, lb per cu ft	7.09	8.87
Average density of bales after drying, lb per cu ft	5.18	5.95
Average water-free density of bales, lb per cu ft	4.50	5.17
Static pressure, inches water column	1.25	0.41
Moisture content before drying, per cent (wet basis)	36.6	41.7
Moisture content after drying, per cent (wet basis)	13.1	13.1
Total water present before drying, lb	189.3	260.8
Total water evaporated by seven days drying, lb	139.6	206.0
Total water present after drying, lb	49.7	54.8
Water present after drying, lb per cu ft	0.68	0.78
Water evaporated, lb per cu ft	1.91	2.92
Water evaporated, per cent of water present before drying	73.8	79.0

Heat Removal by Forcing Air Through and Around Bales. By referring to Table 2 it may be seen that bales stored in bin 4, where air was forced around bales, were of higher initial moisture contents and densities. It is believed that these factors accounted for the higher internal bale temperatures in bin 4 prior to the start of drying. Thermocouples were inserted to determine the temperatures in the centers of bales in both bins. Fig. 8 shows the periodic decrease of these temperatures during the first 45 min following the start of drying as related to the temperature of the air forced into the two bins.

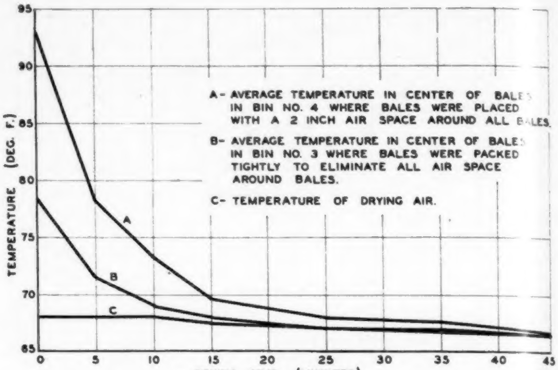

Fig. 8 Rate of heat removal from baled alfalfa by forced atmospheric air as determined by periodic temperatures in center of bales

Thus it was found that the center-of-bale temperatures were decreased about as rapidly in bin 4 where free passageways were provided for the flow of air around bales as in bin 3 where bales were stored tightly together to make air flow through the bales as much as possible. Whether or not this would hold true if the total air flow through the two bins were proportionately decreased remains to be determined.

No observations were made of whether or not air actually penetrated any of the bales where free passageways were provided around the bales. It is likely that some air did penetrate the bales in this bin in the light of the periodic decrease of center-of-bale temperatures about equal to those observed in bin 3 where air emerged from the upper surface of bales in the top tier at a velocity around 200 fpm.

SUMMARY

Following these preliminary tests this paper has been prepared because of the need for information on the drying of baled hay, particularly in North Carolina. It is believed that these results will prove helpful to other investigators planning work of this nature. However, it must be clearly understood that this information has resulted from a preliminary study and is subject to revision as more complete and accurate data are obtained.

1 Bales of alfalfa hay varied in density from 6.60 to 12.09 lb per cu ft at time of baling in a conventional baler. With hay treated in the field as nearly equal as practical, the moisture content of hay, when baled, varied from 31.9 to 45.1 per cent.

2 Hay of higher moisture content when fed into the baler resulted in bales of greater density. There were indications that the density of bales tended to increase, to some extent, with an increase in length of bales.

3 Bales become increasingly more uniform in density as drying progresses. The difference between maximum and minimum density of all bales, when baled, was reduced 48.8 per cent by seven days drying with forced atmospheric air. At the same time the average moisture content of bales was reduced from 39.16 to 13.07 per cent.

4 The observed data indicate that the resistance of baled alfalfa to air flow is related to the water-free density of the bale as modified by some factor. This factor may result from actual shrinkage in volume of the leaves and stems or respiration loss of dry matter during drying, or both.

5 The over-all individual resistances to air flow of any given number of bales will not necessarily become more uniform as drying progresses.

6 Drying by forcing air around bales is as effective as drying by forcing air through bales of alfalfa under the conditions reported. The static pressure in drying by forcing air around bales was only one-third of that encountered in drying by forcing air through bales. *(Continued on page 307)*

New Designs for Barn Hay Drying Systems

By E. L. Barger, C. K. Shedd, and Henry Giese
MEMBER A.S.A.E. FELLOW A.S.A.E. FELLOW A.S.A.E.

THE work reported in this paper started at the first A.S.A.E.-sponsored barn hay-curing conference at Knoxville, Tenn., in December, 1944. Wallace Bunnell of the Louden Machinery Co., B. P. Hess of the Westinghouse Electric Corp., and the authors formulated preliminary plans at that time to investigate the design, construction, and testing of prefabricated metal duct systems. Plans were completed immediately following the Knoxville conference and work started on the design of a metal duct system. Others contributing were J. B. Davidson and R. W. Louden.

Of the many problems involved, not many have been solved, but some progress has been made, and this paper is presented in answer to inquiries about the success of the venture. The objectives were to (1) build a prefabricated system, (2) construct it of metal or a material that could be prefabricated satisfactorily, (3) make one that was simple, consisting of a few standard parts to facilitate manufacture and installation, (4) design it to give satisfactory air distribution, and (5) build one that would distribute air with minimum air resistance.

It was found that many of the accepted design values, if worked into a metal prefabricated system, were not compatible with ease or economy of manufacturing. In order to give sufficient comparative data, it was agreed that one unit would be built that included desirable features from a manufacturing standpoint, and a second one would be built incorporating some principles of design that seemed desirable from a theoretical standpoint but were questionable from the standpoint of production. Therefore, two systems were designed and built. This work was done in the experimental shops of the Louden Machinery Co., Fairfield, Iowa. System 1 was installed in the west horse barn on the Iowa State College campus and system 2 was installed in the barn at the swine research farm of the Iowa Agricultural Experiment Station at Ames. A paper and cardboard model did yeoman service in ironing out some of the design problems. Actually this small model gave data that formed the basis of the design of the commercial system and to a large extent influenced the second or theoretically preferable system.

This paper was presented at the Third Barn Hay-Curing Conference sponsored by the American Society of Agricultural Engineers, at Chicago, Ill., December, 1946. Authorized for publication as Journal Paper No. J-1457 of the Iowa Agricultural Experiment Station, Project No. 922.

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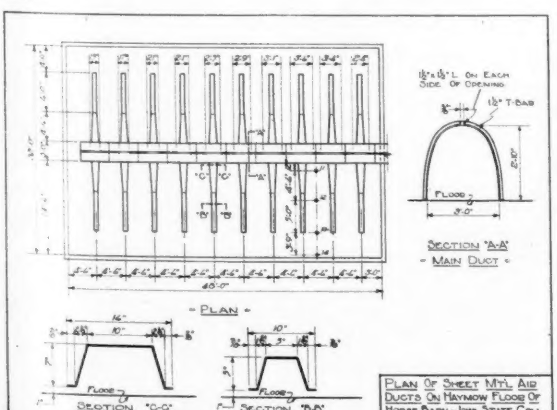


Fig. 1 Metal duct system (No. 1) on the haymow floor of the horse barn at Iowa State College

The desirability of uniform section in the main tunnel and in the laterals as far as possible is apparent from a manufacturing standpoint. It was desired to have a system that would consist of a relatively few standard parts. Fig. 1 shows the plans of the west horse barn system, the one that seemed to show greatest promise from the manufacturing standpoint. The main duct is made up of T-iron ribs placed on 54-in intervals and 20-gage galvanized steel sheet made up in 54-in lengths with openings placed centrally for the laterals. The dimensions on the illustration give the size of the main duct. The laterals consisted of inverted troughs with steel supports or feet that provided the space under the duct and also provided means of nailing the duct to the barn floor in the desired position. The laterals consisted of two sections. The first section was tapered and the outer section straight. The dimensions are shown on Fig. 1.

The main duct is uniform in cross section throughout its length and has a cross sectional area of 7.4 sq ft.

Fig. 2 shows the prefabricated uniform section duct system ready for installation. There are only four major parts. These consist of straight sections of lateral, tapered inner sections of lateral, the T-iron hoops, and the flat sections which form the cover for the main tunnel.

Ease of assembly or installation seemed to be a desirable feature. Either of the experimental units could be installed by two men in one-half day. Fig. 3 shows the hoops nailed to the floor with the nailing plates, the cover sheets for the main duct have been nailed to the floor the full length of the main duct and are ready to be formed over the T hoops.

Fig. 4 shows the workmen forming the sheet metal sides to the contour of the hoops. Following this operation, the top edges are drawn together with stove bolts leaving an opening about ¾ in wide. The width of the opening was varied from end to end as shown in the floor plan. It was assumed that the duct would tend to load up at the outer end and therefore the opening in the top of the duct was reduced at the outer end.

Fig. 5 shows a workman laying the lateral duct on the floor. These were placed and each foot or angle iron support was nailed to the floor. The finished uniform section system is shown in Fig. 6.

A floor plan of the second experimental system (No. 2) is illustrated in Fig. 7. This system was installed in a barn

TABLE 1. STATIC PRESSURES SHOWING AIR DISTRIBUTION IN THE EXPERIMENTAL DUCT SYSTEM WITH AND WITHOUT HAY LOAD

Location number*	No hay load		6 to 7-ft settled hay	
	System 1†	System 2†	System 1	System 2
	Hundredths of inches water column			
	Ends of laterals			
1	14	12	54	15
2	16	23	61	23
3	17	19	62	27
4	21	19	62	26
5	22	19	62	23
6	25	20	64	21
7	24	21	61	25
8	25	23	58	23
9	25		62	
10	28		57	
	Floor			
9		2		5
10		3		5
11	−8	5	18	4
12	0	3	22	0
13	1		15	
14	0		5	

*See Figs. 1 and 7.

†System 1 has main duct of uniform section; system 2 has tapered main duct.

TABLE 2. STATIC PRESSURES SHOWING AIR DISTRIBUTION IN EXPERIMENTAL DUCT SYSTEM (NO. 1), WITH 6 TO 7-FEET SETTLED HAY LOAD AND TWO SPACINGS BETWEEN DUCT AND MOW FLOOR

Location number*	Static presure in hundredths inches of water: 1-in opening under laterals	2½-in opening under laterals
1	54	49
2	61	58
3	62	57
4	62	61
5	62	57
6	64	64
7	61	66
8	58	57
9	62	62
10	57	64
11	18	31
12	22	34
13	15	25
14	5	10

*See Fig. 1.

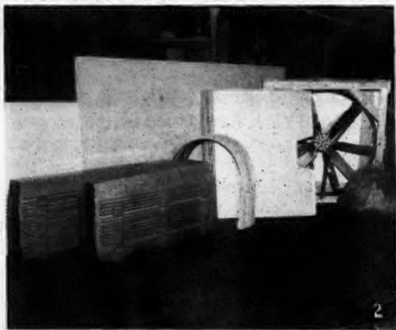
with a door off center at the mow floor level. A hay chute interfered with the location of the main duct, and the first two laterals were blocked off and eliminated. Since the system was somewhat larger than required in the barn, it was necessary to block off the laterals on one side, at a distance of 5 ft from the wall. This system was designed with a uniform taper throughout the main duct, and Fig. 7 shows the dimensions at sections A and B. The laterals were tapered of one-piece construction, and the sections at three points are shown at the lower part of Fig. 7. The ends of the laterals were blocked with small wooden blocks. The laterals were placed ½ in above the floor, using metal support brackets. They were nailed to the floor the same as the other system. A series of T-iron hoops were used in this system, no two of them being the same size. The erection procedure for the tapered system was identical to uniform section system (No. 1). Fig. 8 shows the completed tapered system on the barn floor.

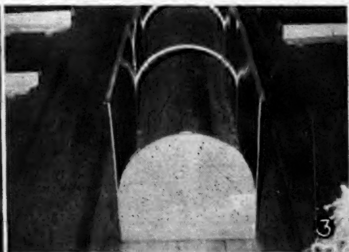
An experimental Allis-Chalmers engine blower was made available for test work. This engine was used in connection with system 2, the tapered duct system at the swine farm. In a search for a satisfactory connection between the fan unit on the ground and the main duct on the mow floor, a du Pont product called "Ventube" was suggested by V. S. Peterson, du Pont representative. Ventube is made to convey air into mines and tunnels. A section of this material 15 ft long and 38 in in diameter was obtained. This fit exactly the fan housing and a simple attachment was made to fasten it to the end of the main duct. No attempt was made to provide elbows at either end.

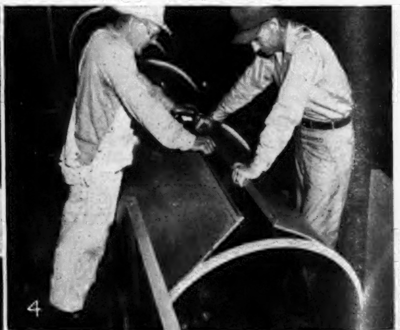
Fig. 9 shows the tube inflated. This setup was used during the 1945 season. It was regular Ventube with a coating suitable for inside use. The tube was used during two drying operations and was left attached to the barn and blower, and exposed to the wind and weather for three months. At the end of this time it showed signs of weather checking and damage. Fig. 10 shows the tube that was used during the 1946 season. This tube has a coating of special formulation to withstand exterior exposure. Sewed into the ends of the tube are 45-deg elbows. It is apparent that the air stream is improved, and in general this second tube gave very satisfactory performance. This tube was also exposed for three months during the 1946 season, and at the end of the season it showed no apparent deterioration. A flexible connection has considerable merit in the ease and simplicity with which the fan can be hooked up to the air duct system.

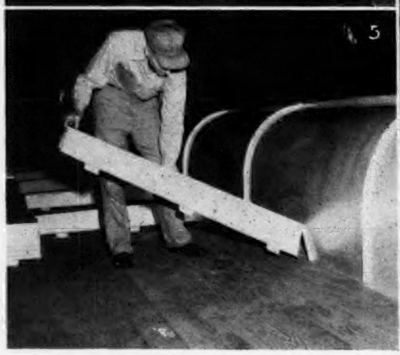
Tables 1 and 2 show static pressures at the ends of laterals. The numbered locations 1 to 10 are lateral numbers in the uniform duct system (Fig. 1), No. 1 being closest to blower. Locations 11, 12, 13, and 14 were midway between a pair of laterals and varying distances out from the main duct as shown in Fig. 1. In the tapered duct system, numbers 1 to 8 are lateral numbers and 9 to 12 locations on the floor midway between laterals (Fig. 7).

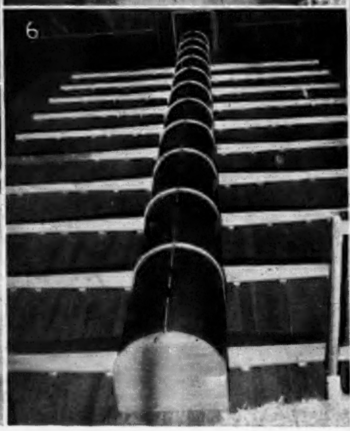
Table 1 shows static pressures at the designated points in the two systems with no hay load and with a 6 to 7-ft settled











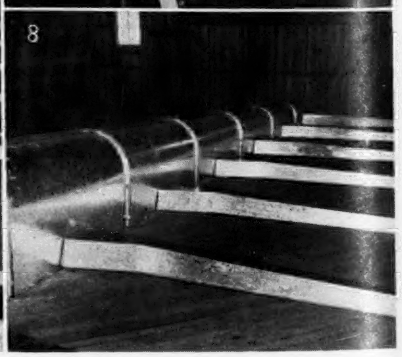


Fig. 2 An experimental prefabricated system ready for installation. It consists of four major parts: straight sections of laterals, tapered sections of laterals, T-iron hoops, and flat sections for covering the main duct. (Photo courtesy Louden Machinery Co.) • Fig. 3 Prefabricated system in process of installation. T-iron hoops have been nailed to the floor and sheet steel cover is ready to be formed • Fig. 4 Workman joining sheet steel panels over main duct • Fig. 5 Workmen laying the laterals. They are nailed to the floor • Fig. 6 The completed uniform section prefabricated duct system in place on the barn floor • Fig. 8 This view shows the completed tapered duct system installed

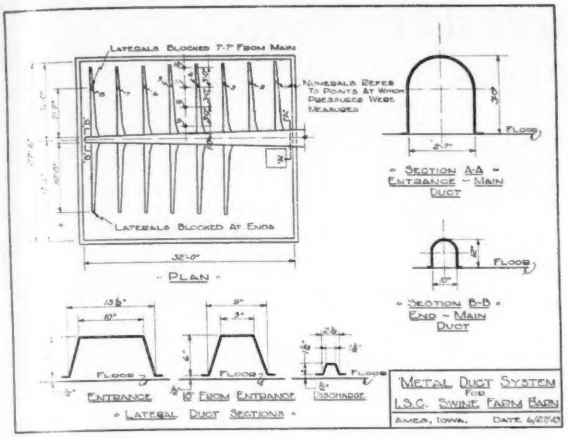


Fig. 7 Metal duct system (No. 2) for the Iowa State College swine farm barn

hay load. Air flow was approximately 15 cfm per sq ft of mow floor in system 1. It was not measured in system 2. The fact that pressures in system 2 were lower than in system 1 may have been due to differences in rate of air flow and to differences in resistance to air flow of different lots of hay. In these tests system 1 had 1 in space under the laterals and system 2 had ½ in. All pressures were measured through ¼-in copper tubing run under the hay and leading to the location point. It is apparent that the no-load distribution of the air is best in the tapered-duct system. This could have been influenced by the tapering of the ducts and also by the smaller openings under the laterals. In both systems with 6 to 7-ft hay load, the air distribution seems to be quite uniform with the exception of No. 1 laterals. The No. 1 or uniform section main shows the greatest improvement in uniformity of distribution with hay load as compared to no load.

Table 2 compares static pressures at the selected points in system 1 with 1-in and 2½-in openings under the laterals and with a 6 to 7-ft hay load. There was very little difference in the distribution as indicated by the static pressures with the two different spacings, but there was a significant difference between the pressures in the ducts and the pressures under the hay. The important point is the pressure difference between the duct and the floor. With the 1-in opening the pressure difference is roughly 0.4 in, while with the space increased to 2½ in it is approximately 0.3 in.

The two metal prefabricated duct systems have gone through two years of service and seven barns full of hay have been cured. System 1 has handled four crops and the other three. Both long, loose hay and baled hay have been dried. The hay quality has been good and no sign of spoilage has been found that would indicate faulty air distribution in either system. One crop of baled hay was placed on the uniform system (No. 1) by dropping the bales on it from the overhead track. A few small dents in the sheet metal were observed but no serious damage was done to the system.

The work done thus far on the metal prefabricated systems indicates that a relatively simple prefabricated system can be built with a great part of the duct work of uniform section which will give sufficient uniformity of air distribution.

Drying Baled Hay

(Continued from page 304)

7 Following the start of drying, heat was removed about as rapidly from the center of bales where free passageways were provided for air to flow around bales as that where free passageways were not provided.

8 All the hay dried in these tests was of good final quality considering the rainfall it was subjected to in the field. There was no mold evident to the eye in any bales, and the aroma was good.

9 The relative effectiveness of drying by forcing air around bales and the lower resistance pressures encountered make it imperative that investigations in the immediate future be focused on this method of drying baled hay.

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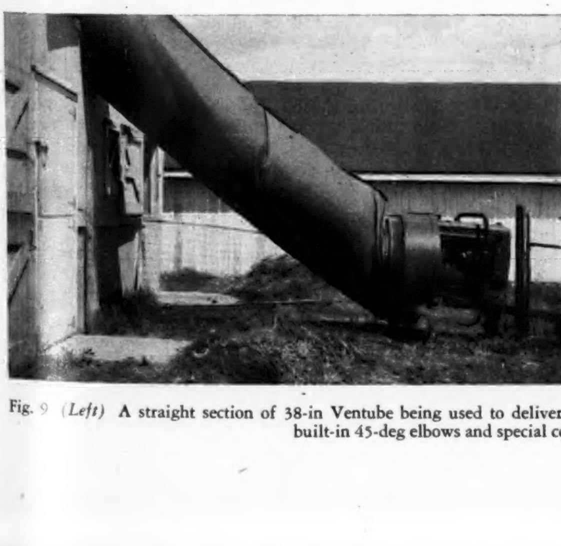
New Federal and State Bulletins

"Maintenance and Operation of the Plow and One-Way Disk." Agricultural Extension Bulletin No. 32, University of Saskatchewan (Canada). Contributed by the department of agricultural engineering. Evan A. Hardy, professor and head of the department says of this bulletin: "You will note we have brought our draft data tables on pages 10, 16, and 20 up to date and that we describe a new machine which has been built here in Western Canada and called the one-way disk harrow, which is taking the place of the one-way disk in many instances. We would be able to supply copies to all those interested in this bulletin."

"Flame Cultivation" by Harold T. Barr, head of agricultural engineering research, Louisiana Agricultural Experiment Station, Louisiana Bulletin No. 415, April, 1947.

"Septic Tank Sewage Disposal Systems," by O. J. Trenary, is published as Extension Bulletin 390-A, Colorado A. & M.. College.

"Homemade Fertilizer Applicator," by O. J. Trenary, is Circular No. 147-A, Extension Service, Colorado A. & M. College.



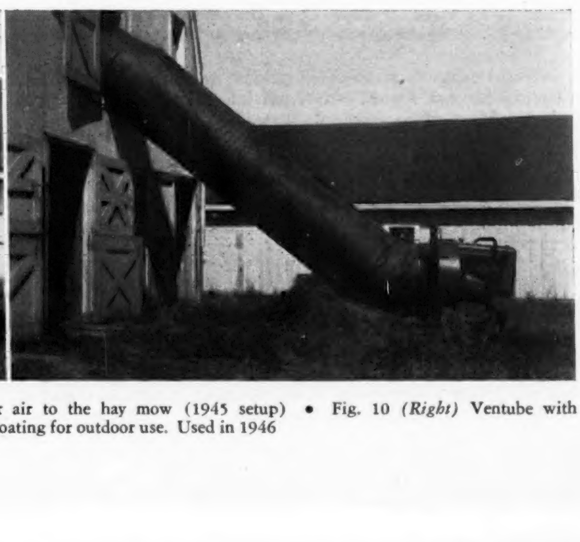


Fig. 9 *(Left)* A straight section of 38-in Ventube being used to deliver air to the hay mow (1945 setup) • Fig. 10 *(Right)* Ventube with built-in 45-deg elbows and special coating for outdoor use. Used in 1946

Economics of Straw Utilization

By E. C. Lathrop
ASSOCIATE A.S.A.E.

HUNDREDS of new uses for paper, container, and building board products were developed during the war years. Thousands of new uses will result from the intensive industrial research on cellulose now under way. These materials are in short supply even at a present annual production of 19 million tons. The plant expansion program of the paper and board industry involves hundreds of millions of dollars. The present annual consumption of forest products exceeds the annual growth rate. Costs of pulp wood have approximately doubled during the past five years because of increases in labor and transportation expenses.

Of the crop residues, wheat, rye, rice, and seed flax straws appear exceptionally well suited to contribute to the manufacture of paper and board. This statement is supported by the following facts:

Board manufacturers the world over recognize that the highest quality of 9-point corrugating is made from wheat or rye straw. Even before the war, Holland, Belgium, Germany, Italy, South America, and South Africa manufactured fine book, writing, and other papers by pulping these straws. A mill in Java has for many years been producing fine book and writing papers from rice straw. Much of the paper produced in England during the war was from cereal straws. The mill equipment was not well suited to this purpose, and one of the larger English paper companies is now building a mill designed to use wheat straw to make fine book and writing papers. Seed flax straw has proven to be the best source in this country from which to produce cigarette paper and one of the best for condenser, Bible, and certain other fine papers. A satisfactory insulating building board was manufactured for some years from wheat straw in Missouri. Recently at the Northern Regional Research Laboratory processes for manufacturing building materials of exceptional merit from straw have been developed.

Prior to 1829, paper was manufactured from linen and cotton rags. In that year the first process for making paper from straw was invented, and a mill started operations in Pennsylvania. The first mills producing paper from wood started to operate in the United States during the 1860's. Wood was easier to collect than straw, and better paper for wrapping, bag, and general use could be made from wood than from straw. Shortly after that date the use of straw for papers, other than for butcher paper and board, declined; and almost the entire effort in paper manufacture was directed to the use of wood pulps. However, because of the superiority of straw as a raw material for corrugating board, the strawboard industry in this country has, thus far, withstood the competition of wood pulp. Indeed, until 1926, strawboard had a monopoly on corrugating box manufacture. At that time official freight classifications permitted use of a board made from waste chestnut chips from which the tannin was extracted. A few years later the use of kraft pulp was officially recognized.

At present 25 strawboard plants operate in the Middle West. They use about 700,000 tons of straw, principally from wheat. Most of these plants were built 30 to 50 years ago when farmers were glad to sell their straw stacks and when wheat was a major crop in this area. Furthermore, these plants are located near metropolitan centers where boxes are used. With the changes in farming practice beginning in the 1930's, particularly with the change from wheat to soybeans and other diversified crops, coupled with the introduction of the combine, the strawboard industry has encountered extreme difficulty in straw procurement.

The development of the American cigarette paper industry by Straus and his associates, using seed flax straw as a raw material, is an outstanding achievement in the paper industry. This waste had been investigated numerous times previously, and it was generally considered that economics was against the use of seed flax straw for fine paper manufacture. To Lawrence Dixon, one of the Straus associates, belongs much of the credit for making the process possible, his contribution being that he worked out and effectuated the collection of the straw and its processing into the valuable tow fiber now used for the paper process.

The function of our Regional Research Laboratory is to develop the use of farm products, particularly surpluses, to bring a greater dollar return to the farmer. To effectuate industrial utilization, commercial processes must be developed and every aid must be given to industry and to agriculture to establish and maintain mutually profitable business relations. Having had long industrial experience in the development and manufacture of board and paper products and having contributed to the successful industrial methods of collecting, handling, and storing sugarcane bagasse, the author approached the organization of the Agricultural Residues Division of this Laboratory in 1939 from a practical viewpoint. In 1940 a trip was made to each strawboard plant to learn the problems of this industry. Close contact was also established with the new cigarette paper industry. The outstanding problem of these industries was the economics of their fibrous raw materials, mainly that of adequate collection.

In 1940 the harvester-combine was finding extensive use in the Middle West and the familiar straw stack was less in evidence on the landscape. For some reason, the development and manufacture of a pickup baler, the companion machine to the combine, had lagged not only to the discomfiture of the strawboard industry but also, and more important, to the farmer who needed millions of tons of bedding. Furthermore, the methods of collecting and baling combine straw were new, and the quality of this straw was very poor. Consequently, contact was established with members of the Farm Equipment Institute and through cooperation of some of their members and of agricultural experiment stations, a number of valuable experiments on straw collection were conducted. The concurrent importance of developing pickup balers for hay has resulted in the development of a number of light, one-man pickup balers. However, the package made by some of these is too low in density for industrial use. It is also evident that present methods and machines for collecting some 300,000 tons of seed flax straw are inadequate.

In my talks with executives of the strawboard industry I know they recognize that some of their present difficulties arose on their own doorsteps. The old methods of straw procurement resulted in very small return to the farmer. In many cases mills usually had no direct dealings with farmers. When changing conditions came to Midwestern farmers, they had no incentive to keep serving industry. Today the mills pay more freight on their straw than they pay the farmer or the straw collector. I believe that mill executives are remedying this situation and that better mutual understanding between industry and the farmer is being developed.

The strawboard industry recognizes that little research has been carried out and that mill operations will benefit from better operating control. The Northern Laboratory has undertaken to assist the industry in this phase of work and to investigate raw materials other than wheat straw. Some practical progress has been made. At the same time, research directed towards the manufacture of fine paper pulps has yielded results which indicate the possibility of obtaining a yield of 50 per cent of screened bleached (Continued on page 310)

This paper is based on an informal presentation before a joint meeting of the Fibrous Agricultural Residues Committee of the Technical Association of the Pulp and Paper Industry and representatives of the Power Machinery Department of the Farm Equipment Institute, on the subject of straw collection and baling, held January 13, 1947, at the USDA Northern Regional Research Laboratory, Peoria, Ill.

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Collection and Quality of Straw for Strawboard

By S. L. Aronovsky

THE strawboard industry in the past few years has found its ingenuity taxed to the utmost in dealing with the economic problems of straw procurement. The future of the industry, in fact, may hinge largely upon what is done to facilitate this procurement from points less distant from the mills, and in initiating such methods of handling straw that it will be of better quality and available in larger quantity. Successful and increased utilization of straw will result only as these problems are solved. The work done to date on collection and quality of straw offers encouragement for the belief that these problems will be solved. Without doubt the most difficult part of remedying the situation lies ahead.

Of the 63 million tons of wheat straw grown in the United States in 1945, 37.5 million was harvested by binders and combines. Only 10 million tons was used on the farm or sold. Of this amount, 3 million tons, or approximately 30 per cent, was baled, this representing only about 8 per cent of the total straw cut. About 2 million tons of straw was baled in Ohio, Indiana, Illinois, and Michigan, the four states in which about 80 per cent of all the strawboard mills in the country are located. It would appear that these mills would have sufficient baled straw for their requirements in their own back yards. This is far removed from the actual facts, for a large proportion of the straw baled in these states is used on the farm for bedding, litter, and other farm purposes.

There was considerable concern in Ohio a few years ago regarding the shortage of straw for farm purposes brought about by lack of suitable methods and equipment to collect and bale the combined straw. A sizable portion of the baled straw is sold for bedding in livestock trucks and railway cars and for packing purposes. The mills in these four states, therefore, had to go as far north as the Dakotas, as far south as Texas, and as far west as Colorado to obtain the amounts of straw required to keep them in operation. During the war the strawboard industry was able to stand the added baling and transportation costs involved in getting the raw material from long distances, but such costs will have to be lowered considerably if these mills are to compete with industries making other types of pulps which can be used for the same purposes as straw pulp. During this period also a number of substitute raw materials were tried, but in general these proved less satisfactory than wheat straw.

This critical situation was brought about mainly by the arrival of the combine and the lack of suitable baling equipment to handle combine straw economically. When the effects of the combine began to be felt in the Middle West in the early 1930's, some strawboard mills went to farm equipment manufacturers requesting equipment suitably designed to pick up and bale the combined straw. The manufacturers replied that too few balers were involved to make their manufacture profitable. The situation is different now; the entire strawboard industry is united in that request.

The Northern Regional Research Laboratory came into this picture more than five years ago. Conferences were held with most of the strawboard mills and with some of the farm equipment manufacturers. A number of collection and baling experiments were conducted. The results of these tests and other data[1]* showed how both the farmer and the strawboard industry would benefit from proper and economical methods of collecting and handling straw.

This paper is based on an informal presentation before a joint meeting of the Fibrous Agricultural Residues Committee of the Technical Association of the Pulp and Paper Industry and representatives of the Power Machinery Department of the Farm Equipment Institute, on the subject of straw collection and baling, held January 13, 1947, at the USDA Northern Regional Research Laboratory, Peoria, Ill.

S. I. ARONOVSKY is in charge, pulp and paper section, agricultural residues division, Northern Regional Research Laboratory, U. S. Department of Agriculture; also chairman, Fibrous Agricultural Residue Committee, Technical Association of the Pulp and Paper Industry.

*Superscript numbers refer to appended references.

Through the efforts of the Northern Laboratory, and with the encouragement of the strawboard industry, a committee was organized in the Technical Association of the Pulp and Paper Industry to deal with the problems of straw pulp and strawboard manufacture. This committee consists mainly of the top technical men, operators, and managers of strawboard mills, representing more than 80 per cent of the total strawboard production.

A preliminary round-table discussion of the strawboard problems, held in New York City, was attended by more than 100 interested persons; most of the 3½-hr session was devoted to a discussion of collection and baling of straw[2]. At a two-day meeting of the committee held at the Northern Laboratory in 1945[3], this subject was again the main item of discussion. Later, in April, 1946[4], when the top management of most of the strawboard companies met at the Northern Laboratory, preliminary specifications for straw bales satisfactory to all present at that meeting were developed. The purpose of these specifications was to serve as a basis for discussion with the farm equipment manufacturers. The specifications were sent to all strawboard mills in the industry for their criticism or approval. With one or two exceptions all of the mills gave definite approval of them, and even in the exceptions, most of the specifications were accepted. The specifications for straw bales were as follows:

Size of Bale to be 16x18x42 in. Most of the mills approved this size, although one or two thought that a 17x22-in bale would be more satisfactory. One other mill thought that a 14x18-in bale would make for easier handling in the mill.

Weight of Bale to be 80 lb. There was some feeling of doubt in some of the replies whether an 80-lb bale could be made in the above dimensions; however, it was decided when these specifications were set up that the goal should be to obtain as compact a bale as possible, and 70 to 80 lb would be acceptable.

The Chaff in Straw to be Under 5 Per Cent. There is no difficulty in obtaining this specification when combined straw is used, because this type of material contains considerably less chaff than when straw is baled from the stack.

Height of Stubble After Cutting or Mowing to be 3 in. Most replies agreed on this specification. One or two thought that in some localities it might be difficult to leave a stubble as low as 3 in and not include weeds with the straw. One reply carried a recommendation of a 5-in stubble. The lowest possible stubble is important, however, because the best portion of the straw, in so far as the manufacture of paper or board is concerned, is that portion closest to the ground. Therefore, anything that can be done to decrease the height of the stubble without involving too many weeds, or too much dirt or trash, would be highly desirable.

Bale Ties Should be Wire. The experience in the strawboard mills with twine-tied bales has been generally disappointing.

Moisture Content of Straw. This last specification states that moisture in the baled straw should be about the same as at harvest time; in other words, the straw should be collected as soon as possible after harvesting the grain. It is realized, of course, that the manufacturer of baling equipment would have no control over the moisture in the baled straw. However, this item was included in the specifications mainly as information for equipment manufacturers with regard to the quality of straw desired and required by the mills. The wheat plant is relatively dry at the time of combining, the grain containing approximately 11 to 14 per cent moisture and the straw the same or perhaps slightly more. Straw with a moisture content of 18 per cent or less, if relatively free from green weeds, will not ferment or decompose readily. Therefore, if straw is collected and baled at the time of harvesting the grain, it will be sound and in the best condition for use in paper or board manufacture.

All of the technical problems of the strawboard industry, as in other industries, have not been solved, but it is firmly believed by those of the Northern Laboratory who have been working on the problem and by many workers in the strawboard industry, that if good, sound, uniformly baled straw can be obtained by mills, and if this straw is then protected from weathering and rainfall during storage, a very large proportion of the technical difficulties in straw pulp and board mill operations will disappear.

It is assumed that a satisfactory baler will be of the one-man type. The objection of the strawboard industry to the present one-man baler is that it does not make a sufficiently compact bale, particularly with twine used as the tie. Although the twine-tied bale produced by the one-man baler is apparently a very satisfactory package for hay, it is not satisfactory to the strawboard mill. Straw bales must be transported to mill yards where they are piled in large ricks of 300 to 500 tons. The bales at the bottom of the rick must withstand considerable pressure. In the course of processing, bales are removed from the ricks, transported to the mill digester building, and then brought into the digester room by conveyor systems. To withstand this treatment the bale must be strong, compact, and not easily broken until the bale tie is removed.

There is another branch of the pulp and paper industry which uses agricultural residues as its raw material. The cigarette paper industry, which uses seed flax straw, has grown phenomenally in the past few years and is expanding at a fairly rapid rate in producing other types of fine papers. The straw requirements of this industry for the past year was approximately 350,000 tons, equal to about half of the wheat straw used by the board industry. The cigarette paper manufacturers have carried on a considerable amount of work on the procurement of seed flax straw, and they have developed a number of improvements in methods of collecting this raw material. One of these improvements is a dechaffer to remove most of the chaff from threshed seed flax straw before baling. The methods of collecting and baling this straw are generally similar to those pertaining to the cereal grain straws.

The economic collection and baling of straw is a practical problem. It must be solved if straw is to survive as a raw material for the corrugating paper and other straw-using industries. It is no longer a problem peculiar to a few isolated strawboard mills, but is of vital concern to the whole industry and to the cigarette paper manufacturers as well. Both of these industries will cooperate fully with the farm equipment manufacturers in working out this problem. A suggested mode of attack is to form a committee of representatives of the strawboard and cigarette paper industries, of the farm implement manufacturers, and of the Northern Laboratory to act as liaison between these groups. Such a committee, empowered with authority to make the necessary decisions, should go far toward solving this problem of straw collection and baling.

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Straw Utilization

(Continued from page 308)

pulp based on the original straw. This pulp will be useful chiefly for blending with wood pulp to produce improved magazine, book, and writing paper. Based on some preliminary results given by this Laboratory to Dutch and to English papermakers, the principles of the process have already received industrial application. A Dutch mill is producing more than 100 tons of fine paper a week from straw by the process. The English results are not quite so good, but this is due to lack of proper equipment. One of our American mills is arranging to try out this process before long.

Several groups in both Kansas and Nebraska are giving serious consideration to the use of the Northern Laboratory's process for producing board products. Such developments would require the use of about 200,000 tons of straw. Veneer used for making wire-bound boxes is becoming scarce owing to depletion of forests, and expensive because of more profitable uses for such veneer. The Northern Laboratory is cooperating with the box industry in an endeavor to produce a satisfactory box board from straw. Present results are fairly favorable. If this industrial requirement could be supplied from straw as a raw material, another million tons of straw would find use.

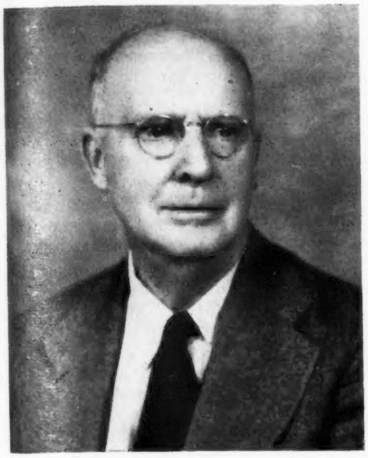
From this discussion it will be seen that with some improvement in the economics of straw collection and handling the day is not far distant when straw can contribute markedly to this rapidly growing board and paper industry. Statistics for wheat straw in 1945 show a total of 63 million tons of straw produced, of which only 3 million tons was baled, although a total of 10 million tons was sold or used on the farm. Thirteen million tons was cut by the binder, much of which was blown into stacks; 21 million tons was uncut stubble standing after combine harvesting. Of course many farmers find use for this straw as stubble mulch or for plowing back into the soil to maintain fertility, but in many areas such practice is of no benefit or other practices are preferred. For example, the Ohio Agricultural Experiment Station now recommends that the standing combine straw stubble be removed at once from legume cover crops. It has been found that this stubble not only degrades the legume hay but also markedly depresses its yield. How much straw was burned or wasted in 1945 is unrecorded. Straw is a national annual resource; its best and most profitable uses should be found.

Naturally the farm equipment manufacturers have been more concerned with the farmer's problems than with those of industries using farm products. Now with definite prospects of tonnage utilization of certain crop residues it would seem that a broader viewpoint is warranted. In 1940 it appeared to the author that the logical way to develop this mutual understanding of the problem was to arrange for the strawboard and farm equipment industrial representatives to sit down together, define the problems of each group, and find a practical and profitable solution. First, it was necessary for the members of the strawboard industry to consolidate their thinking. This has been done in the T.A.P.P.I. Fibrous Agricultural Residues Committee. This conference between the T.A.P.P.I. Committee and the Farm Equipment Institute is therefore, the culmination of long planning. A solution of this particular industrial problem will open the door for greater use of agricultural residues both on the farm and by industry.

The farmer must obviously receive value for his straw. This can be done by reducing transportation costs and by securing better quality straw which will give higher yields and better quality paper. We must realize that the woods operations in obtaining pulp wood have reached a high state of efficiency in mechanization and labor-saving brought about by many years of intensive study. These operation are almost as highly industrialized as the manufacturing operations in production plants of the farm equipment or strawboard industries.

The present operations in collecting straw are very inefficient; all that results in the several handlings of straw during collection is loss and quality damage. It seems clear that the responsibility of improvement in methods and machines for crop residue collection falls on the agricultural engineers and the equipment manufacturers, but the problem is much simpler than if one had now to work out our present pulpwood collection methods. If, when the farm equipment manufacturer develops collecting machines and methods adapted for farm use, it is borne in mind that possible industrial use and eventually greater industrial use is involved, development will proceed in the right direction. Industry will not pay more for agricultural residues than for its present raw materials, and because residues are for the most part new to industry, it will probably pay somewhat less. With efficient collection methods the farmer can receive a reasonable cash profit for a portion of his annual residue crop and industry can use these materials also at a profit.

The 1947 A.S.A.E. Gold Medalists



The American Society of Agricultural Engineers awarded the John Deere Medal to Frank Adams, and the Cyrus Hall McCormick Medal to Henry Giese on the occasion of its annual dinner on June 25, held at Philadelphia, Pennsylvania

FRANK ADAMS HENRY GIESE

WHETHER judged by the length and consistency of his professional career, the national and international significance of his work, the profusion of his technical and popular publications, or the esteem of his colleagues, the choice of Frank Adams, professor emeritus of irrigation in the University of California, as the John Deere gold medalist for 1947 appears as one of surpassing merit. His has been a lifetime of applying the art and science of both engineering and economics to soil in the special realm of irrigation agriculture.

Son of Edward Francis and Delia Ray (Cooper) Adams, he was born September 19, 1875 at Chicago, Ill. His higher education earned him the bachelor of arts degree from Stanford University in 1901 and the master of arts degree from the University of Nebraska in 1906. On June 20 of the latter year he married Amy Belle Hill of Montoursville, Pennsylvania. They are the parents of one daughter and three sons, the latter all U. S. Navy officers in the late war.

His lifetime of devotion to irrigation agriculture began in 1900 with employment by the Division of Irrigation Investigations, U. S. Department of Agriculture. This was shortly after its organization under direction of the late Dr. Elwood Mead, who continued all his life as a close associate and abiding inspiration to Professor Adams. Those were times when irrigation farming, as we know it now, was in its infancy. Principles and patterns had to be evolved for successful enterprises, along with equity in the allocation of costs and benefits. In all of this Frank Adams pioneered broadly, bringing to bear his special training in economics.

In the years through 1909, in various capacities, he made investigations and prepared reports covering many aspects of irrigation in California, Utah, Colorado, Wyoming, and Nebraska. From 1910 to 1924 he was in charge of cooperative irrigation investigations in California. Some of the studies in these investigations were of irrigation districts, use and duty of water, measurement of irrigation water, soil moisture in relation to irrigation, water rights, irrigation resources of the state, pumping for irrigation, land settlement in irrigation projects, irrigation legislation and irrigation organizations.

It was in 1916 that he became Professor Adams, organizing what is now known as the Division of Irrigation at the University of California, and continuing as its head until 1936. From 1928 onward he has been irrigation economist in the Giannini Foundation of Agricultural Economics of the same university. He also has been irrigation economist in the California Agricultural Experiment Station. From 1926 to 1940 he was consulting engineer (later economist) for the U. S. Bureau of Reclamation. His most recent consulting work has been with the California State Division of Water Resources.

Superposed and interspersed were other important assignments and activities, two of them *(Continued on page 312)*

IN CHOOSING Henry Giese to be the 1947 recipient of the Cyrus Hall McCormick gold medal, the Jury of Awards of the American Society of Agricultural Engineers may well have considered both the aggregate amount of his contributions to the advancement of agricultural engineering and the balanced variety of avenues along which he has exercised his talents. Yet it may be surmised that it is above all else the recognition of a great teacher.

Son of George F. Giese, a country doctor, Henry was born December 23, 1890, at Danville, Iowa. His education started in the public schools there, continued at Howe's Academy at Mt. Pleasant, Iowa, and culminated with degrees from Iowa State College at Ames. These include the B. S. in Architectural Engineering in 1919, M. S. in Agricultural Engineering in 1927, and in 1930 the professional degree of Architectural Engineer. His courses included two years in electrical engineering and additional work in mechanical engineering.

His career as an educator began long before completion of his own education. In 1911-12 he was an instructor at Howe's Academy. Then for four years he was director of manual training in the public schools at Ames. Meanwhile, in 1914, he started to spend his summers training teachers in the same subject at Iowa State College, being in charge of the final years of 1917 and 1918. In 1918 came a hiatus for military service.

Dovetailed, during the years 1916-19, Mr. Giese worked half time in the engineering extension service of Iowa State College, paralleling the pursuit of his own studies. Then, until 1922, came connection with the U. S. Veterans Bureau wherein he was concerned with vocational rehabilitation of disabled soldiers.

In 1923 he returned to Iowa State College as instructor in engineering mathematics, and began the connection with its agricultural engineering department where he now is professor. From this otherwise continuous service he had leave of absence from June in 1929 to September of the following year to serve as senior engineer directing the Farm Structures Research Survey by the U. S. Department of Agriculture.

Between these obviously official capacities and his extracurricular and voluntary activities it is hard to draw any sharp line. A moving spirit in the North Central Farm Structures Committee, he has served as its secretary, as acting administrative advisor, and as chairman of its Midwest Plan Service subcommittee. To his efforts are credited in large measure the inauguration and development of the Regional Farm Building Plan Services and the Regional Farm Building Reserch Committees. These, in turn, pave the way for effective work under the Flannagan-Hope Act.

Other capacities include that of guest professor at the universities of Arkansas and Georgia, member of the committee

on fire prevention education of President Truman's Conference on Fire Prevention, chairman of the farm fire protection committee of the National Fire Protection Association and member of its committee on fire protection engineering education, and member of the agricultural committee of the National Fire Waste Council. Currently he is serving as the official A.S.A.E. representative to the two latter organizations.

Reflecting both his prestige and his practicality are his repeated appearances as speaker at meetings of such organizations as the Iowa and Northwestern Lumberman's associations and the National Association of Mutual Insurance Companies. The Iowa Association of Mutual Insurance Associations had him as speaker at seventeen consecutive annual conventions.

Prominent as a proponent of research, particularly in farm structures, and with a creditable record of his own, yet his major contribution has been in directing the activities of others, and above all his inspiration and development of research workers. He has guided the graduate program of 37 candidates for the master's degree, and a list of their theses is a bookshelf in farm structures engineering.

Speaking with the perspective of some fifteen years following his graduate work, one of them says of Professor Giese that "through his research fellowship program supported by industry he has directed more research and trained more graduate students in farm structures research than any other college professor, and probably more than all others combined. . . .

"His method of graduate training is unique. Believing that graduate students should learn to think for themselves in preparation for their life's work, his students are not only permitted but required to select their own problem for research. The students also soon learn that advice is given only when possible solutions are first submitted by the students themselves. . . .

"Henry's wide experience in consulting with industry also turned to the students' assistance when job hunting began; from his broad knowledge of industry's operations he was able to give the students a preview of industry requirements and an entree to prospective employers. . . . His practice of sharing authorship with his students in reporting on research is further evidence of his unselfishness and his desire to help them get recognition in the profession."

Thus Professor Giese appears as author or joint author of about a hundred federal and state bulletins, books, and articles in technical and popular journals. His name has appeared consistently through the years among the authors of papers published in the official A.S.A.E journal, AGRICULTURAL ENGINEERING.

His honorary memberships include Phi Kappa Phi for scholarship, Sigma Xi for research, Tau Beta Pi for engineering, Gamma Sigma Delta for agriculture, and Phi Mu Alpha for music. Fraternally he belongs to three of the Masonic orders. His church affiliation is Presbyterian.

Professor Giese is a member of the American Society for Engineering Education and of the Iowa Engineering Society, and he is a registered professional engineer of Iowa. Along the years of his active participation in affairs of the American Society of Agricultural Engineers, he has been vice-president, chairman of the Structures Division, chairman and member of many committees. At present he is a member of the Society's Council.

In his close contacts and professional connections with the building industry, notably as agricultural engineer and consultant to a great lumber company, Professor Giese has given great impetus to cooperation between industry and education, to their mutual advantage and to the advancement of agriculture. His alignment with practical farming is even more intimate and extensive.

In 1843, three years before its admission to statehood, one of his grandfathers came to Iowa to farm. His other grandfather did not become an Iowa farmer until ten years later, having delayed a decade to engage in the California gold rush. Now Henry is thrice a farmer, having acquired three farms which are operated under his direction.

Mr. Giese's family consists of his wife, nee Dollie F. Kelly, and three children — Barbara Ruth (Graves), William Henry, and Mary Joan.

Frank Adams — 1947 Deere Medalist

(Continued from page 311)

in Europe. In 1919 he was a member of the U. S. Army Educational Corps in France. Then, in 1927, he went to Palestine as a member of its advisory committee on agricultural colonization. In the period 1928-30 he served as consulting engineer on the International Water Commission for the United States and Mexico.

Professor Adams was chairman of the California Economic Research Council in 1930-32, and from 1933 through 1937 was a member of the executive council of the Institute of Irrigation Agriculture, American Farm Bureau Federation.

Equally impressive are his connections with technical societies. He was enrolled as a member of the American Society of Agricultural Engineers in 1925. He is, or has been, a member of the American Society of Civil Engineers, the American Association for the Advancement of Science, American Geographical Society, Section of Hydrology in the American Geophysical Union, American Academy of Political Science, and the California Academy of Sciences.

One of his special interests has been the Commonwealth Club of California, founded by his father, Edward F. Adams. In 1908-1909 he was editor of its transactions; in 1912-1914 was chairman of its section on conservation and from 1920 to 1924 headed its section on irrigation; in 1930 and 1931 he was chairman of its section on water resources, and he has just ended two years as chairman of the committee on water conservation and irrigation development in its section on agriculture. He has been a member in both the Berkeley and Davis branches of the Faculty Club of the University of California. He holds a decoration as Officer du Merite Agricole, and is a member of the Tau Beta Pi.

As a writer, Frank Adams has been consistent and, in the aggregate, prolific. Starting in 1903 is a list of publications whereof he was sole or joint author. It contains 121 titles, and more than a hundred of them obviously deal with irrigation, with some of the others probably embracing it. They include federal and state bulletins, circulars, and reports, and articles in publications ranging from the proceedings of technical societies to popular farm papers.

Men who know Professor Adams well speak of him not only as a research scientist, engineer, and educator, but as a leader, pioneer, and citizen. They emphasize his combination of intensely scientific attitude with happy relations among colleagues and subordinates, and with a generous spirit toward those of differing views. All are agreed on the value of his lifetime contribution toward the advancement of irrigation agriculture. One of them says:

"For 30 years I have admired him for his personality, his progressive spirit, and his devotion to agricultural science. For many years he was the leader among agricultural engineers in the investigations of irrigation science and practice, not only in charge of such investigations in the University of California, but stimulating and encouraging such investigation elsewhere."

Another remarks that "Professor Adams has been one of the persons who had the vision to look ahead and see problems approaching so that work could begin on them before they became too acute." Still another mentions that "his study of irrigation districts and his influence in the early formulation of irrigation district legislation have been outstanding accomplishments."

"He is a man of pronounced qualities of leadership and, furthermore, that rare quality of industrious application to detail. . . . I do not know of any worker in the irrigation field who can approach his contributions to our knowledge of agricultural engineering problems in the 17 arid and semi-arid states of the West," writes a man who worked on important assignments with Professor Adams.

Particularly among the western members who best know him and his work, Frank Adams is revered for his part in the development of agricultural engineering as a profession and for his ardent support of the American Society of Agricultural Engineers and its ideals. In 1925 he served as chairman of the Society's Pacific Coast Section, and in 1931 as chairman of its Committee on Land Settlement.

RESEARCH NOTES

A.S.A.E. members and friends are invited to supply, for publication under this heading, brief news notes and reports on research activities of special agricultural engineering interest, whether of federal or state agencies or of manufacturing and service organizations. This may include announcements of new projects, concise progress reports giving new and timely data, etc. Address: Editor, AGRICULTURAL ENGINEERING, St. Joseph, Mich.

A.R.C. OPEN HOUSE FOR A.S.A.E.

NEW developments in plant and soil science, some of which may have agricultural engineering implications, were discussed briefly by R. M. Salter, chief, Bureau of Plant Industry, Soils, and Agricultural Engineering, USDA, when the Washington (D.C.) Section of the American Society of Agricultural Engineers, held its concluding luncheon meeting of the year at the USDA Agricultural Research Center, Beltsville, Md., on June 11.

One phase of the Bureau's research mentioned by Dr. Salter was use of plant hormone substances to delay fruit dropping, speed ripening, or increase size. Basic experiments on the physiological effect of applications of organic compounds in minute quantities resulted in 2,4D, toxic to dicotyledonous plants, use of which as a weed killer has been expanding rapidly. Commencing on unpublished results of some recent preliminary experiments, he hinted at the fascinating possibility of some time growing corn by preparing seedbed, planting, and fertilizing in one operation, followed by an airplane or aerosol application of 2,4D to eliminate cultivation, after which the next mechanical operation would be harvesting.

Research work directed towards combining crop-raising operations and reducing the total number takes on new importance, Dr. Salter explained, as soil science studies the effects of compaction of the soil in producing corn and other row crops. A great deal of work remains to be done, and there is reason to predict that wholly new types of farm machines may eventually need to be designed as more is learned about plant growth and its relationship to soil manipulation.

Members of the staff of the Agricultural Engineering Divisions held open house for their fellow A.S.A.E. members at the Fertilizer Placement Laboratory, and after luncheon Soil Conservation Service staff members piloted the group over the terraced fields of hill culture research. Tobacco studies on this sandy loam soil, somewhat droughty, include three-year rotation, one-year rotation in which various winter covers are turned under in the early green manure stage and in the late green manure stage, and continuous tobacco in rows on 1 per cent grade.

Of interest to Washington A.S.A.E. members looking over the farm after the program was a portable forage dehydrator mounted on pneumatic rubber tires which was operating in an alfalfa field near one of the dairy barns. The Division of Farm Electrification is using the machine in cooperation with the Bureau of Dairy Industry on studies of the nutritive value of forage cured and harvested in various ways, including field curing, mow drying, and preservation as wilted silage.

COTTONSEED HANDLING WITH SMALL AIR PIPES

Aimed at keeping cottonseed pure and uncontaminated, a mechanical system of seed handling with small air pipes developed by engineers of the Bureau of Plant Industry, Soils, and Agricultural Engineering at the U. S. Cotton Ginning Laboratory, Stoneville, Miss., is now in use in more than 500 gins in the cotton belt. More of the small-pipe systems are being installed every year. In operation they consume less than half the power required in older seed-handling systems.

For handling grains, granular bulk materials, and various kinds of trash, the small-pipe systems are economical and trouble free. They enable the cotton producer and ginner to preserve the purity of the cottonseed because the equipment is self-cleaning. They have adequate capacity for moving from 70 to 160 lb of cottonseed per minute from the gins—as fast as the cotton is ginned.

Being light in weight, small-pipe systems are portable and can be used for loading from trucks to railroad cars at inland trackage points and for emptying the cars at seed breeders' treating and delinting plants, where the seed may be carried to storage bins and later moved on to grading, sterilizing, and other processes at rates of handling to suit the capacity of the plant.

Cottonseed has been successfully handled for distances up to 700 ft by these small-pipe blowing systems. Installation costs are very little more than for the larger pipe and fan systems which have been commonly used. The older types operate on 10 to 15 hp, but only 3 to 7 hp is required with the small pipes.

SCIENTIFIC APPLE STORAGE

More Pacific Northwest apples in prime condition are becoming available at eastern markets throughout the late winter and spring as growers make increasing use of handling and storage recommendations by the Bureau of Plant Industry, Soils, and Agricultural Engineering and Farm Credit Administration. These recommendations involve a new principle called "reversed air" cooling.

Apples of the Delicious variety are particularly sensitive to storage conditions. Research has shown, however, that ripening can be retarded and storage life lengthened by rapid reduction of fruit temperature to from 30 to 32 F. Growers following the new practices are able to make the most effective use of refrigeration.

The new designs for installation specifications for cold storage houses aim at faster and more uniform fruit cooling by gravity or forced circulation of refrigerated air. Large quantities of air and delivery and return ducts spaced as far apart as possible increase air velocity and hasten cooling. Reversed air cooling provides for input of cold air or removal of warmed air through the same ducts. Reversal of the air movement at regular intervals, usually of about 3 hr, makes possible use of colder air for rapid precooling without danger of freezing, as none of the fruit is exposed continuously to the incoming cold air.

Fruit is harvested at optimum maturity and sorted into blocks for early, middle, and late shipment so that preferential treatment can be given apples to be held longest. The best fruit is put in storage at once, preferably the morning after picking when the night air will have removed some of the heat. It should reach storage temperature within a week and be kept there until shipped to market under refrigeration.

Apples for late fall or midwinter sale have second place in the cooling schedule. They are brought down to storage temperature less rapidly but get additional refrigeration later as it can be spared from the late-shipment block. Bureau specialists recommend that the part of the apple crop of lowest storage quality be packed as received from the orchard and shipped early with little or no cooling in storage.

NEW AGRICULTURAL YEARBOOK

The series of USDA Yearbooks of Agriculture, interrupted by the war, is resumed with publication on May 31 of "Science in Farming," Yearbook of Agriculture, 1943-1947. Alfred Stefferud is editor of the 1,094-page, well-illustrated volume which represents something of a departure in form and content from "Soils and Men" (1939), "Keeping Livestock Healthy" (1942), and the intervening prewar yearbooks.

The 135 short articles in "Science in Farming" are grouped under the following headings: Backgrounds, Animals, Plants, Trees, Soils, Insects, New Products, Food and Clothing, New Practices, and Conclusions. A foreword by Secretary Anderson, "Life More Abundant," sets the approach of the book towards helping farmers and city workers to know more about each other.

Reports on agricultural engineering research include such titles as Ways to Till the Soil, by F. L. Duley and O. R. Mathews; Managing Surface Runoff, by D. B. Krimgold; Irrigation in the West, by George D. Clyde; Paper from Flax, by Arthur C. Dillman; Some New Farm Machines, by R. B. Gray; Simplifying Farm Work, by E. C. Young and L. S. Hardin; Machines for Sweet Potatoes, by O. A. Brown; New Fertilizer Machines, by Glenn A. Cumings; Cotton Ginning, by Charles A. Bennett; Air War Against Pests, by H. H. Stage and Frank Irons; Blowers for Insecticides, by W. L. Popham; Machine-Made Forests, by Paul O. Rudolf; Equipment for Oil Crops, by I. F. Reed; New Sugar-Beet Machinery, by S. W. McBirney; Sugarcane Culture, by George Arceneaux; Storing Grain in Small Bins, by E. R. Gross and H. H. Walkden; The Cold Storage of Apples, by W. V. Hukill and Edwin Smith; Shell-Cooled Potato Storage, by Alfred D. Edgar; and Prefabrication on the Farm, by John A. Scholten.

* * * *

In the direction of bringing the results of agricultural research into use by farmers on individual farms, 75 county agents, assistants, and supervisors from Michigan spent three days at the Agricultural Research Center, Beltsville, early in June. C. V. Ballard, state leader of county agent work, Michigan State College, brought the visitors in, and their program was arranged by Karl Knaus of the USDA Extension Service, field agent for the North Central States. The county agents were interested in getting first-hand information on a large number of research projects in such fields as soils and crops, engineering, livestock, poultry, dairy, and entomology as background for interpreting and translating current developments and knowing what to look for.

At the Engineering Laboratory the group saw a movie on freezing food prepared by the Bureau of Human Nutrition and Home Economics, a film from California on how to build a walk-in freezer, and the agricultural Engineering Divisions' film on their research projects at Beltsville and in the field. Truman E. Hienton discussed the work on hay drying, tobacco curing, and use of bactericidal lamps. Wallace Ashby explained the parallel investigations on housing requirements of dairy cows, poultry, and swine, and told of recent developments in crop handling and storage, showing models of experimental cribs. J. Robert Dodge reported progress on the revision of the Northeast Plan Exchange, pointing out that the plans included will be suitable to the Michigan climate, and announced the status of various bulletins in the new housing series. Roy B. Gray covered the field of investigations in mechanical equipment, some of which are cooperative with the Michigan station.

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NEWS SECTION

George Rietz Takes Office as New A.S.A.E. President

WELL known throughout the agricultural engineering profession, and especially in the field of farm electrification, George A. Rietz, manager of the farm industry division, apparatus department, General Electric Company, is the new president of the American Society of Agricultural Engineers. He took office on June 25, when he received the president's gavel from Dr. Mark L. Nichols, retiring president, at the conclusion of the Society's annual dinner and meeting at Philadelphia, Pa.

Mr. Rietz has been active in progressively responsible positions in farm electrification for more than twenty years, and has been active in the American Society of Agricultural Engineers, its Rural Electric Division, and its North Atlantic Section since 1928. His interest in this field dates from his days as an undergraduate student in electrical engineering at South Dakota State College.

GEORGE A. RIETZ

At the beginning of his junior year, in September, 1924, he was employed as program director and announcer for the State College radio station KFDY, serving primarily the farmers of the state. In June, 1925, he undertook additional work with the late R. L. Patty, as field man for the South Dakota state test line for determining practical applications of electric power and equipment on farms. He continued in both of these positions along with his studies until his graduation in 1926.

In September, 1926, George Rietz began student engineering work with the General Electric Company. His association with the Company has been continuous since that time.

From June to December, 1927, he conducted the Company's first rural electrification course, to train men for this work with electric utilities. Then after completing the Company's sales training course he was transferred to Chicago as district rural electrification specialist, covering thirteen central states and working with colleges, power companies, farm equipment manufacturers, and other organizations interested in extending to farms the uses and advantages of electric power.

Returning to Schenectady in 1930, he was placed in charge of the rural electrification section of the Company's central station department. Later he was made general assistant to the manager of the customer division, central station divisions, and from there progressed to his present position.

In A.S.A.E., Mr. Rietz was elected and re-elected to serve as secretary-treasurer of the North Atlantic Section for the years 1931 to 1935. In 1935-36 he was chairman of the Section, and vice-chairman of the Rural Electric Division, advancing to the position of division chairman for 1936-37. In September, 1936, he also represented the Society at the Third World Power Conference, and was a speaker on its program. He was elected vice-president of the Society for the two-year term, 1938-40. In that capacity he also served as a member of the Council.

President Rietz is also active in a number of other organizations; currently he is chairman of the farm electrification committee of the National Electrical Manufacturers Association, chairman of the farm management subcommittee of the American Society of Mechanical Engineers; a director in the Better Farm Buildings Association, and a member of the farm buildings committee of the Producers Council.

A.S.A.E. Meetings Calendar

July 22 to 24 — Dairy Housing Conference, Hotel Loraine, Madison, Wis.

October 23 and 24 — Pacific Northwest Section, Davenport Hotel, Spokane, Wash.

December 15 to 17—FALL MEETING, Stevens Hotel, Chicago.

A.S.A.E. Annual Meeting Provides Forward Look at Agricultural Engineering

THE center of agricultural engineering in the United States moved east to Philadelphia for the annual meeting of the American Society of Agricultural Engineers, June 22-25.

A concentration of more than 500 registered, to turn the lobbies and meeting rooms of The Benjamin Franklin into a combined staff conference center on present and future engineering development in, by, and for agriculture and its related industries.

Sunday, June 22, was a handshaking period of reunions and introductions, building up to a climax in the buffet supper and social hour that evening. Special acknowledgment of the courtesy which made this buffet supper possible is due the following organizations: A. B. Farquhar Co., S. L. Allen & Co., Inc., C. A. McDade Co., Hertzler & Zook Co., New Holland Machine Co., Pennsylvania Power and Light Co., Philadelphia Electric Co., and Westinghouse Electric Corp.

Retiring President M. L. Nichols keynoted the meeting with an address picturing the opportunities, obligations, and needs of agricultural engineering in a current postcombat reconversion period characterized by continuing economic warfare and confusion of objectives.

H. A. Lyon, director, Detroit Agricultural-Industrial Foundation, pictured the program of that organization as one of enlightened selfishness for industry. He indicated the importance of agricultural income as an influence on volume of business in industry; gave examples of practical cooperation with agricultural leaders, and noted the beginning of an industrial engineering approach to an analysis of farm operations with a view to improving equipment, methods, and over-all efficiency.

A refreshing variation from the problems common to most of the audience was provided by Dr. Ross E. Moore, chief of the technical collaboration branch, Office of Foreign Agricultural Relations, U. S. Department of Agriculture, in a talk on "Some Engineering Phases of Tropical Agriculture."

Reports on the progress, activities, and interests of the A.S.A.E. were the main feature of the short business meeting. They included the report of the Secretary-Treasurer and reports of several chairmen of professional and administrative committees.

Research, a dominant interest throughout the meeting, was featured in the second general session. "The Farm Equipment Industry's Interest in Agricultural Research Programs" was presented in an address by W. A. Roberts, president, Farm Equipment Institute, and vice-president, Allis-Chalmers Mfg. Co. He indicated a strong interest, on the part of the industry, in research to provide better information on the jobs to be done by farm equipment and the operating conditions and requirements to be met.

Dr. F. A. Brooks, agricultural engineer, California Agricultural Experiment Station, followed with a paper on "Research Procedures for Cooperative Projects with Limited Personnel," which reflected the application of a wealth of study and experience to a present-day problem in research administration.

Awards announced and presented at the Annual Dinner by President Mark L. Nichols included the John Deere Medal to Frank Adams; the Cyrus Hall McCormick Medal to Henry Giese; A.S.A.E. Paper Awards, to C. E. Frudden, John E. Nicholas, Dwight D. Smith, H. B. Walker, and Stanley A. Witzel, and the FEI Trophy to the Oregon Student Branch of A.S.A.E.

Following the awards, Paul J. Newton, master of ceremonies, introduced H. W. Prentis, Jr., president of Armstrong Cork Co., a man combining exceptionally wide business, technical, and educational interests, who delivered the address of the evening, speaking on "The Price of Freedom." He found the audience responsive to his thesis that the price of freedom is eternal vigilance, with particular attention "to justice, moderation, temperance, frugality, and virtue and by a frequent recurrence to fundamental principles."

In the last item of business on the program, President Nichols turned over the presidential gavel and duties of his office to the new president, George A. Rietz; and President Rietz, as his first official act, presented Dr. Nichols with one of the Society's "Past-President" emblems.

The evening ended with a short new sound and color movie showing

NEWS SECTION

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the varied scenic and recreational attractions of Portland, Oregon, and vicinity, the locale of the next annual meeting of A.S.A.E., in June, 1948. It was presented with brief supplementary comments by Clyde Walker, chairman of the committee on local arrangements for that meeting.

It is impracticable to attempt to do justice, in the limited space available, to the special interest features of the meeting, including sessions of all four technical divisions, the College Division, the student group program and dinner, Committee on Hay Drying, Committee on Meteorology, Committee on Research, Council and Cabinet Meetings, women's program, and other features; or to give full credit to various members of the local arrangements committee and others for their individual and collective contributions to the success of the meeting.

Frank Kranick Made Life Fellow of A.S.A.E.

HAVING joined the American Society of Agricultural Engineers in 1912, and having filled a requirement of the By-Laws of the Society, namely, of paying membership dues in the organization for 35 consecutive years, the Council of the Society at its meeting last month elected Frank N. G. Kranick a Life Fellow.

Mr. Kranick served the Society as its President during the year 1920, the year in which the Society's monthly journal, AGRICULTURAL ENGINEERING was launched. Mr. Kranick and J. B. Davidson, first president of the Society and then serving as its secretary, took the initial steps in establishing the publication.

Recently, at his own request, Mr. Kranick, who had spent many years in the employment of the J. I. Case Co., was relieved of his responsibilities with that organization. While he has no definite plans for the immediate future, it is his intention to keep in close touch with the activities of the farm equipment industry through his many personal contacts, travel, and the management of his farm in Racine County.

Mr. Kranick has always taken an active interest in the affairs of the farm equipment industry, having served as secretary of the Power Machinery Department of the Farm Equipment Institute for nearly 10 years, and for several years recently as chairman of the Institute's Committee on Safety.

Mr. Kranick is the author of many articles on farm machinery which have appeared in columns of the implement trade press, and he is also the author of a book, entitled "Farm Equipment for Mechanical Power," published in 1935.

Byrne New Chairman of Virginia Section

AT THE spring meeting of the Virginia Section of the American Society of Agricultural Engineers held at Roanoke, May 16 and 17, S. H. Byrne, associate professor of agricultural engineering, Virginia Polytechnic Institute, was elected the new chairman of the Section. Three vice-chairmen were elected as follows: Ralph J. Blair, agricultural engineer, Appalachian Electric Power Co.; G. W. Halsey, Connecticut territory supervisor for J. I. Case Co., and G. D. Kite, assistant extension agricultural engineer, Virginia Polytechnic Institute. U. F. Earp was re-elected secretary-treasurer. The new Section nominating committee consists of R. B. Davis, Jr., L. L. Koontz, and J. N. Selby.

A total of 72 people registered for the meeting, representing eight different states and the District of Columbia, as well as 24 different commercial concerns and federal and state agencies.

The program for the opening session on Friday, May 16, included a paper on wiring and rewiring the farmstead by J. R. Walters and L. A. Walls of the Monongahela Power Co. Hugh R. Roberts, field engineer, Portland Cement Association, spoke on concrete in home construction, and the farm and home equipment situation was discussed by A. H. Hemker, agricultural engineer, General Electric Co. This program was followed by the Section dinner and entertainment in the private dining room of the Hotel Roanoke.

Following a business meeting on the second day, May 17, a program of two papers was presented. George B. Nutt, head of the agricultural engineering department, Clemson Agricultural College, and chairman of the A.S.A.E. Southeast Section, addressed the meeting on the interrelationship of the state, regional, and national activities of A.S.A.E. in the promotion of agricultural engineering progress. This was followed by a talk on agricultural engineering in soil and water conservation by John K. Abernathy of the U. S. Soil Conservation Service.

Mechanization in Canadian Agriculture

MECHANIZATION in Canadian agriculture was featured in the March, 1947, issue of the "Agricultural Institute Review", bimonthly publication of the Agricultural Institute of Canada. Many of the articles are by A.S.A.E. members in Canada, including G. N. Denike, J. E. Beamish, P. E. Roy, J. L. Thompson, D. S. Horne, W. Kalbfleisch, A. Banting, J. A. Roberts, J. Macgregor Smith, L. G. Heimpel, W. S. Lavigne, N. E. Macpherson, W. C. Wood, W. B. Denyes, E. A. Hardy, and C. G. E. Downing.

More Ag Engineers for Michigan

A. W. FARRALL, head of the agricultural engineering department at Michigan State College, recently announced the addition of three new members to his staff. They are Leroy J. Wallen, extension specialist in rural electrification; Theodore J. Brevik, extension specialist on farm structures plan service and on tourist and resort program and Harvey Kapphahn, supervisor of REA safety and job training.

Farm Electric Conference Plans

THE second National Farm Electrification Conference will be held at the Claypool Hotel, Indianapolis, Ind., on Tuesday and Wednesday, October 7 and 8, with an estimated 500 agricultural, educational, farm publication, industrial, contracting, and merchandising leaders in attendance.

Hassil E. Schenck, president of the Indiana Farm Bureau, is chairman of the 1947 Conference and Geo. W. Kable, editor of "Electricity on the Farm" is vice-chairman. Mr. Kable served as chairman last year.

The program will offer addresses by prominent farm electrification leaders and a series of forum discussions covering "what is being done and what further needs to be done to make electricity the force in agriculture that it is in industry". Arrangements for the program are being made under direction of Truman E. Hienton, head, farm electrification division, U. S. Department of Agriculture.

Objectives of the conference are two-fold: (1) to search for, discuss, and promote tools and techniques designed to assist agriculture through the increased efficiency and economic use of electricity and (2) to promote acquaintance and understanding among participants of the conference and others engaged in farm electrification, and the use of electrically operated equipment and appliances for farm and home purposes.

In keeping with a policy established last year, the conference will refrain from discussing matters pertaining to the extension of electric service to farmers. This subject, which includes the job of increasing the capacity of farm lines and of improving the quality of electric service to farmers, is recognized as being essentially an activity of private and public power suppliers. Therefore, it is outside the scope of the conference.

It is hoped that conferences of this character will give rise to programs of action which participating organizations can put into operation for the benefit of farm families and agriculture generally.

The American Society of Agricultural Engineers will participate in the conference as one of its sponsors along with a dozen other professional, business, agricultural, and government organizations.

Schaenzer New D. C. Chairman

AT a meeting of the Washington (D.C.) Section of the American Society of Agricultural Engineers held at the USDA Research Center at Beltsville, Md., on June 11, J. P. Schaenzer, head, electro-agriculture section, technical standards division, USDA, Rural Electrification Administration, was elected the new chairman of the Section for the ensuing year. J. R. McCalmont, agricultural engineer, division of farm buildings and rural housing, U. S. Department of Agriculture was elected vice-chairman, and the new secretary-treasurer of the Section is W. D. Potter, hydraulic engineer, Soil Conservation Service (Research), USDA.

Southern Executives Urge Agricultural Engineering Studies

AGRICULTURAL engineers looking ahead will be particularly interested in the implications of a report submitted in May to the Southern Association of Science and Industry, by its committee on agricultural research. This report by and to influential executives in the South summarizes its specific recommendations as follows:

"Based upon those timely and current problems, the solution of which seems to promise the greatest dividends in economic gain, the agricultural research program of every state in the South should include one or more projects from each of the following fields: (1) Increased use of power and improved farm machinery; (2) efficiency standards in operating family-size farms essential for increasing per capita incomes; (3) specifications for establishing and operating agricultural industries and services."

Subsequent discussion amplifies briefly on the need and suggested projects in each of these fields.

Dean Paul W. Chapman of the college of agriculture, University of Georgia, served as chairman of the committee, which included four other university executives and eight representatives of agricultural-industrial interests. Each of 12 southern states and the District of Columbia were represented by one man on the committee. The report is printed on a pocket or letter-size, single-sheet folder convenient for distribution and reference. *(News continued on page 318)*

NEWS SECTION

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Farm Structures School in September

A THIRD farm structures school or conference, under the sponsorship of the Farm Structures Division of the American Society of Agricultural Engineers, will be held at the University of Illinois, Urbana, September 15 to 18, inclusive. Room reservations for the conference can be made direct with the Urbana-Lincoln Hotel, or the University's agricultural engineering department will find private or boarding club rooms for those who desire them.

The program and other arrangements for the conference will be announced soon.

Safe Operation and Tractor Maintenance in 4-H Club Work in New York

A SERIES of tractor maintenance and safe operation training schools recently completed in New York state trained 1100 4-H Club members in 27 counties, reports Carlton M. Edwards, 4-H specialist in agricultural engineering, New York State College of Agriculture.

The schools were planned and conducted jointly by the state and county agricultural extension services, the American Oil Company, and the New York Farm Equipment Dealers Association.

Charles R. Lund, Sr., manager, farm sales department, of the American Oil Co., and Robert C. Burnette, secretary, N.Y.F.E.D.A., both A.S.A.E. members, were active in the program.

The project started in December, 1946, with four leader training meetings at different locations about the state. Club leaders trained at these meetings followed through in their counties with one-day schools and contests for local 4-H Clubs.

In-Service Farm Electric Training Program

A TRAINING program in farm electrification, especially prepared to give agricultural extension agents, vocational agriculture teachers, and rural electric service organization personnel practical information about profitable uses of electric service on the farm, has just been released by the Edison Electric Institute, 420 Lexington Ave., New York City, Grover C. Neff, president of the Institute, has announced.

The Institute's training program, as presented in a comprehensive manual, consists of two days of instruction. A complete schedule, with a detailed outline of the subjects recommended, and ample reference material for the guidance of those preparing the course, is included in the manual. The program is adapted for ready expansion to a greater length if desired. The training courses using this program are expected to be arranged either on a state-wide or a county-wide basis. It is expected that the courses will be held at agricultural colleges and experiment stations, where suitable facilities are available, and will be sponsored jointly by the colleges, agricultural agencies, rural electric cooperatives, power companies, and others.

Among the subjects included in the Institute's program are: The present status of farm electrification; basic fundamentals of electricity; wiring and rewiring for the farm; lighting; water systems: home appliances; electric rates; freezing equipment; electrical equipment for poultry and egg production, dairying, and feed and crop processing; electric motors. The manual presents detailed information on many of these subjects and a list of additional pertinent references is provided to aid those teaching the course.

Copies of the in-service training manual are being sent to state directors of extension activities, power companies, and others concerned with agriculture, by the Institute. Additional copies will be made available at $1.50 per copy.

The training program was prepared by a committee consisting of representatives of agricultural agencies and the Farm Section, Edison Electric Institute. Most of them are members of the A.S.A.E.

Personals of A.S.A.E. Members

Sven G. Anderson has accepted a position as field representative of the California State Soil Conservation Commission, with headquarters at Hilgard Hall, University of California, Berkeley. The Commission was created in 1940, but its activities were confined mainly to investigating and reporting on the organization of the present 48 districts in the state, until Mr. Anderson's appointment as field representative in July, 1946. Through his efforts, soil conservation districts are now receiving personal assistance from the state commission with advice and guidance on organization procedures, development of conservation programs, coordination of assistance from other agencies, and on other matters of a non-technical nature. In addition to a background of many years of construction and engineering experience, Mr. Anderson pioneered the soil conservation districts work in central California with rapid advancements in agricultural engineering and administrative work during his eight years with the U. S. Soil Conservation Service. He also served with the U. S. Navy Construction Battalions during World War II.

Miles V. Engelbach, manager, field engineering, the Ruberoid Co., was recently appointed chairman of the Sales Engineering Committee of the Asbestos Cement Products Association, and also chairman of the Subcommittee on Specifications (Committee C-17) of the American Society for Testing Materials.

Christian L. Martin was recently appointed assistant superintendent of the Pennsylvania State College farm. He was previously with the agricultural engineering department of the College.

John T. Murphy has resigned as project engineer for Harry Ferguson, Inc., to take over the retail sales agency for the new Ford tractor and implement at Brownsville, Tenn.

Clarence B. Richey recently resigned as project engineer on hay machinery with Harry Ferguson, Inc., to accept a position in the engineering department of Dearborn Motors Corporation at Detroit.

Harry V. Snow has resigned as implement sales manager, tractor division, Allis-Chalmers Manufacturing Co., to accept appointment as tractor and implement sales manager of the Dearborn Motors Corp. at Detroit. Mr. Snow joined Allis-Chalmers in 1935 as a blockman at the Memphis branch, and six years later he was transferred to the home office at Milwaukee and advanced to the position of assistant implement sales manager in 1941, becoming implement sales manager in 1942.

Herbert N. Stapleton recently resigned as agricultural engineer for the Green Mountain Power Company in Vermont to accept the position of research agricultural engineer of the Massachusetts Agricultural Experiment Station, Amherst. His appointment became effective July 1.

Necrology

JOHN C. BURSICK, assistant professor of agricultural engineering at Oregon State College, passed away suddenly on June 2, after a short illness. He was a native of Oregon, born at Roseburg in 1914. After earning his bachelor's degree at Oregon State College in 1941, he was immediately employed as assistant agricultural engineer in the Oregon Agricultural Experiment Station. In September, 1942, he was called to duty in the U. S. Navy. After his release in December, 1945, in the rank of lieutenant, he returned to his experiment station work and to added responsibility as assistant professor of agricultural engineering at Oregon State College. A Junior Member of the A.S.A.E. since 1941, he had been elected to the grade of Member in 1946. Funeral services were held June 4, with interment in the cemetery at Roseburg.

New Literature

1947 S.A.E. HANDBOOK. Cloth, 822 pages, 5½x8 inches. Illustrated and indexed. Society of Automotive Engineers, New York, N. Y. No price quoted.

This volume follows the form of recent previous annual editions and includes changes and new standards to bring the complete up-to-date standards of the Society together in one volume. Notable among the standards, recommended practices, and general information data brought up to date, are those on the ferrous and non-ferrous metals, the involute splines, lighting equipment standards and tests, automotive felts, tube fittings, and dryseal pipe threads. Among the new standards published for the first time are those for hydraulic brake fluids, involute serrations, automotive steel castings, low alloy, high tensile steel specifications, and mountings for motor vehicle license plates. Current new data on crankcase oil types, copper and silver brazing alloys and arc welding electrodes are published as general information.

ELECTRIC GARDENING. Paper, 32 pages, 6x9 inches. Illustrated and indexed. Puget Sound Power and Light Co. (Seattle, Wash.) No price stated.

A bulletin drafted as a practical guide to beginners in the use of electricity in various phases of gardening. Subjects covered include electric heating in hotbeds, greenhouses, and propagating benches; use of soil heating cable; cold frame diagrams; methods of electric heating of greenhouses; plans and diagram for small electric greenhouse; automatic ventilation - automatic humidifier; electric soil sterilization; new techniques through research; the greenhouse soil; disease control for greenhouse plants, control of insect pests in greenhouse; and farm electrification laboratory at Puyallup.

PROGRAM OF THE VIRGINIA FARM ELECTRIFICATION COUNCIL. Paper, 16 pages, 8½ x 11 inches. Virginia Farm Electrification Council, Agricultural Engineering Department, Virginia Polytechnic Institute, Blacksburg, Va.

Organization and methods used in stimulating progress in rural electrification in Virginia.

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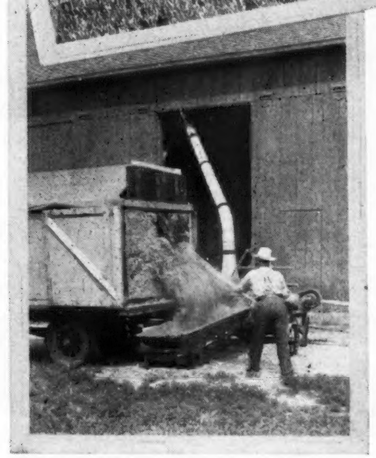

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RATES: Announcements under the heading "Professional Directory" in AGRICULTURAL ENGINEERING will be inserted at the flat rate of $1.00 per line per issue; 50 cents per line to A.S.A.E. members. Minimum charge, four-line basis. Uniform style setup. Copy must be received by first of month of publication.

New Federal and State Bulletins

Poultry House Requirements, a report by the Poultry Committee of the Rutgers University Farm Buildings Institute, New Jersey Agricultural Experiment Station Bulletin 732 (May, 1947). This 26-page boiled down summary of the subject is the product of more than two years of special study by the Committee. Engineering consultants to the Committee are Wallace Ashby and R. H. Driftmier. It is the first bulletin published by the Institute. The Institute was established in 1944 with the cooperation of the John B. Pierce Foundation. Its Advisory Council is organized into poultry, animal husbandry, dairy husbandry, and agricultural engineering groups, with two or three engineers from the latter group assigned as consultants to each of the the other groups. R. H. Driftmier is also vice-chairman of the Council and Lindley G. Cook is secretary.

Proceedings of the Second Annual Industrial-Agricultural Week, sponsored by the Kansas Industrial Development Commission and Kansas State College, November 1946, published as Kansas State College Bulletin, vol. XXI, no. 3 (Feb. 15, 1947). It includes the program address of Harold E. Pinches (Member A.S.A.E.), director of research, Harry Ferguson, Inc., on "Decentralization of Industry and the Interdependence of Industry and Agriculture."

Direct Benefits of Reduced Runoff Losses on Yields of Corn, by R. B. Hickok, I. D. Mayer, and H. Kohnke, published as Purdue University Agricultural Engineering Mimeo No. 8 (April, 1947). It reports results obtained on the Purdue-Throckmorton farm watersheds, which quite a number of agricultural engineers have had the opportunity to visit.

Possibilities of Agricultural Machines, English title of a monograph dealing with the various aspects of the mechanization of Spanish agriculture, recently issued by the Escuela Especial de Ingenieros Agronomos of the Instituto Nacional Agronomico of Madrid, Spain. Copy of this publication was received through Prof. Eladio Aranda Heredia, professor of agricultural engineering at the E. E. I. A. In the first part of this monograph a systematic study of harvesting is made as well as an analysis of the different causes of loss of cereals. Various coefficients of harvest jobs are also given. The second part deals with the cost of the harvest made in accord with the traditional methods followed by Spanish farmers in comparison with work done on a large farm equipped with modern machinery. The use of machinery represents a saving of 50 per cent in the harvesting and 80 per cent in the threshing operations, as brought out in this publication.

North Dakota Frozen Food Unit, by Richard L. Witz, published as Extension Circular AE-22 (April, 1947) of the North Dakota Agricultural College.

Research Notes

(Continued from page 313)

June 11-18 was the week of the National Encampment at Arlington Farms, Virginia, for 4-H Club members. The group of 350, which included two boys, two girls, and the leaders from the 48 states, Porto Rico, Alaska, and Hawaii, made a tour of Beltsville on June 12. At one point in the day the party split so that the girls could visit the research projects of the Bureau of Human Nutrition and Home Economics and see the freezing movie while the boys and leaders saw an exhibit and a movie of agricultural engineering research at the engineering laboratory. R. B. Gray, E. M. Dieffenbach, and J. Robert Dodge told delegates about current work in mechanical equipment and structures, and A. T. Holman discussed farm electrification and the mechanical processing of farm products. Holman also related engineering research to the 4-H Club projects on farm electrification, farm safety, and tractor maintenance.

Applicants for Membership

The following is a list of recent applicants for membership in the American Society of Agricultural Engineers. Members of the Society are urged to send information relative to applicants for consideration of the Council prior to election.

W. J. Adams, Jr., chief engineer, Bolens Products Div., Food Machinery Corp., Port Washington, Wis.

Mando S. Ariens, vice-president and chief engineer, Ariens Co., Brillion, Wis.

H. D. Ayers, agricultural engineer, Dominion Experimental Station, Swift Current, Sask., Canada.

B. Bagchi, graduate student in agricultural engineering, University of Minnesota, University Farm, St. Paul 1, Minn.

J. Douglas Bennett, vice-president in charge of engineering, Empire Tractor Corp., 3700 Main St., Philadelphia 27, Pa.

Bert W. Boyson, irrigation engineer, Agricultural Representative Service, Department of Agriculture, Regina, Sask., Canada.

James H. Carr, Jr., secretary, in charge of engineering and sales, Timber Engineering Co., 1319-18th St., N.W., Washington 6, D. C.

Rex F. Colwick, graduate student in agricultural engineering, A. & M. College of Texas, College Station, Texas.

Sterling Davis, 255 West 2nd North, Logan, Utah.

H. F. Engelking, manager, Bolens Products Div., Food Machinery Corp., Port Washington, Wis.

James W. Greenwood, manager, Southwest Company, P. O. Box 6006, Dallas, Texas.

Joe B. Johnson, agricultural engineer, Public Service Co. of Northern Illinois. (Mail) 1715 Wesley Ave., Evanston, Ill.

Joseph E. Lehoux, agronomist, farm electrification division, Quebec Power Co., Quebec PQ, Canada. (Mail) 229 St. Joseph St.

J. F. la G. Matthee, soil erosion engineer, Division of Soil Conservation and Extension, Department of Agriculture, Box 965, Pretoria, South Africa.

Robert H. Meier, draftsman, experimental department, John Deere Harvester Works, East Moline, Ill.

George H. Miller, tillage and seeding machine specialist, International Harvester Co. (Mail) 1053 West 24th St., Erie, Pa.

Marion Miller, secretary-treasurer, Anderson-Miller Mfg. Co., Box 1751, Spokane, Wash.

Harold E. Nelson, copywriter, Western Advertising Agency, Racine, Wis. (Mail) 418 Wickham Blvd.

F. T. Peterman, Pacific Coast sales manager, Starline, Inc. (Mail) 1743 170th Ave., Hayward, Calif.

A. Rosen, consulting engineer, Vermiculite Industrial Corp. of South Africa, Johannesburg, South Africa. (Mail) 15 5th Ave., Highlands North.

S. K. Sethi, sales and service engineer, John Fowler & Co., Ltd., Leeds 10, England.

Vance N. Shearer, student, Oregon State College. (Mail) Condon, Oregon.

Stanley H. Van Orman, junior engineer, Prairie Farm Rehabilitation. (Mail) Taber, Alberta, Canada.

John E. Wetsel, rural electrification specialist, Tennessee Valley Authority. (Mail) Wilson Dam, Ala.

Jed B. White III, student in agricultural engineering, Oklahoma A. & M. College. (Mail) Kingfisher, Okla.

H. Cecil Wolsey, assistant chief engineer, Battle Creek Works, The Oliver Corp. (Mail) R. R. No. 3, Box 384, Battle Creek, Mich.

Liu Yong-Chi, graduate student in agricultural engineering, Michigan State College, East Lansing, Mich. (Mail) Abbot Hall.

TRANSFER OF GRADE

C. J. Bergschneider, engineer, Bureau of Reclamation, USDI. (Mail) 1545 S. St. Paul St., Denver 10, Colo. (Junior Member to Member)

John W. Crowell, aircraft designer, North American Aviation, Inc. (Mail) 503 E. Fairhaven, Wilmington, Calif. (Junior Member to Member)

T. K. Dimmitt, farm electrification director, Puget Sound Power & Light Co., 5562 Stuart Bldg., Seattle, Wash. (Associate to Member)

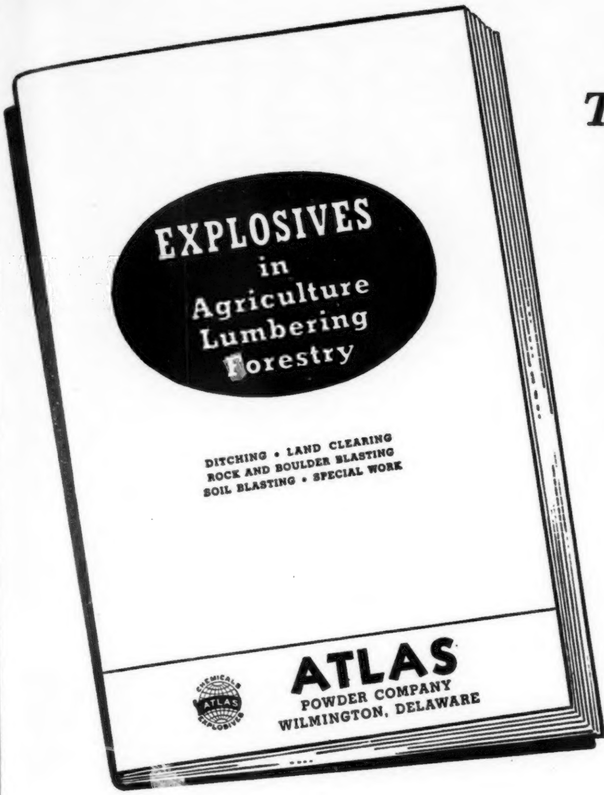
T. S. Forsaith, agricultural engineer, Dominion Experimental Station, Swift Current, Sask., Canada. (Junior Member to Member)

Roy W. Godley, rural service manager, Edison Electric Institute, 420 Lexington Ave., New York 17, N. Y. (Associate to Member)

H. L. M. King, Lieut. No. 12 Coy., RCEME. (Mail) 3217 Dewdney Ave., Regina, Sask., Canada. (Junior Member to Member)

William H. Klingner, professional agricultural and civil engineer, McCann & Klingner, Engineers, 520 W.C.U. Bldg., Quincy, Ill. (Junior Member to Member)

Paul H. Rofkar, chief field test engineer, Harry Ferguson, Inc. (Mail) R. R. No. 1, Port Clinton, Ohio. (Junior Member to Member)



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Personnel Service Bulletin

The American Society of Agricultural Engineers conducts a Personnel Service at its headquarters office in St. Joseph, Michigan, as a clearing house (not a placement bureau) for putting agricultural engineers seeking employment or change of employment in touch with possible employers of their services, and vice versa. The service is rendered without charge, and information on how to use it will be furnished by the Society. The Society does not investigate or guarantee the representations made by parties listed. This bulletin contains the active listing of "Positions Open" and "Positions Wanted" on file at the Society's office, and information on each in the form of separate mimeographed sheets, may be had on request. "Agricultural Engineer" as used in these listings, is not intended to imply any specific level of proficiency, or registration, or license as a professional engineer.

NOTE: In this Bulletin the following listings still current and previously reported are not repeated in detail. For further information see the issue of AGRICULTURAL ENGINEERING indicated.

Attention is invited to the desirability of checking on the housing situation when considering a new location.

POSITIONS OPEN: 1946 MAY—O-503. JUNE—O-506. AUGUST—O-510. SEPTEMBER—O-516. NOVEMBER—O-523. DECEMBER—O-526, 531. 1947 FEBRUARY—O-540. MARCH—O-543, 547. APRIL—O-549, 551, 552, 555, 556, 557. MAY—O-558, 559, 560, 561, 562, 563, 564. JUNE—O-565, 566, 567, 568, 569, 570, 571, 572, 573.

POSITIONS WANTED: 1946 FEBRUARY—W-207. APRIL—W-237. MAY—W-309. JUNE—W-320. SEPTEMBER—W-337. 1947 FEBRUARY—W-373. MARCH—W-382. APRIL—W-383, 386, 387, 389. MAY—W-392, 394, 395, 397, 398, 399, 100, 101, 102, 103. JUNE—W-104, 105, 106.

NEW POSITIONS OPEN

AGRICULTURAL ENGINEER for research in farm use of building materials, to prepare plans and specifications showing this use, and for technical consultation on sales and use, for manufacturer in a north central state. BS deg or higher in agricultural engineering, or equivalent. Experience in design and construction of farm structures. Some extension experience desirable. Want man with inquisitive mind, ambition, good appearance, and ability to meet and talk to others. Opportunity for advancement limited only by ability of the individual. Salary open. O-574

NEW POSITIONS WANTED

AGRICULTURAL ENGINEER desires design, sales, or service work in power and machinery or product processing field. Engineering training in Wisconsin Institute of Techology, 1938-40; University of Idaho, 1940-41. No degree. War service as aviation cadet. One year design and layout work on mining and milling machinery, and on soy bean oil extraction equipment. More than two years in present work on design of animal feed processing plants. No physical defects. Available Aug. 15. Married. Age 27. Salary open. W-107

AGRICULTURAL ENGINEER desires design or development work in farm power and machinery field, with private company. BS deg in agricultural engineering, 1943, BS deg in mechanical engineering, 1947, University of Missouri. Two years enlisted service in Air Corps, mostly as noncommissioned officer. One year in aircraft design. One year half-time work as instructor in farm shop and farm power and machinery. No physical defects. Available September 10. Married. Age 26. Salary $2700 - 3600. W-108

AGRICULTURAL ENGINEER desires service, development, or teaching work in rural electrification; or development, research, or teaching in farm power and machinery, preferably in the Midwest. BS deg in agriculture, 1947; BS deg in agricultural engineering expected Sept. 1947, Ohio State University. More than two years commissioned war service in Air Corps, overseas, as communications officer. Three months summer experience as draftsman, International Harvester Co. No physical defects. Available Sept. 15. Single. Age 27. Salary open. W-109

AGRICULTURAL ENGINEER desires work with private company in rural electric, farm structures, or power and machinery field. BS deg in agriculture, 1947; BS deg in agricultural engineering expected Aug. 1947, Ohio State University. More than three years enlisted war experience, mostly as noncommissioned officer in Air Corps and Signal Corps. Six months as apprentice tool and die maker. No physical defects. Available Oct. 1. Married. Age 25. Salary open. W-110

AGRICULTURAL ENGINEER desires either public or private employment in research, development, or service in the soil and water field, preferably in the western part of the U. S. BS deg in agriculture, with major in agricultural engineering, University of Arizona, 1941. Experience includes research in soil and water conservation, 5 yr; soil survey, 6 mo; tool design and liaison engineering, aircraft manufacture, 6 mo; mining, 3 yr; varied construction, 2 yr. No physical defects. Available on short notice. Married. Age 30. Salary open. W-111

SOIL CONSERVATIONIST desires research, extension, or teaching position in soil and water field. BS deg in forestry, 1940, University of Michigan. Graduate study, University of Tennessee, part time, 1940-41, in conjunction with work in TVA. Experience includes watershed surveys and related work as engineering aide, one year; junior erosion engineer, one year; war service in Navy hydrographic office, one year as officer in charge of training, and one year as officer in charge of control unit; nearly two years as P-2 Conservationist in U. S. Forest Service. Partial disability of neck due to injury in line of duty. Available on short notice. Married. Age 28. Salary $3500. W-112

AGRICULTURAL ENGINEER desires development, research, or extension work in farm power and machinery or extension work in the soil and water field. BS deg in agriculture, 1947; BS deg in agricultural engineering expected Aug. 1947, Ohio State University. Nearly three years war service, mostly as non-commissioned officer in Corps of Engineers. No physical defects. Available Sept. 15. Single. Age 25. Salary open. W-113